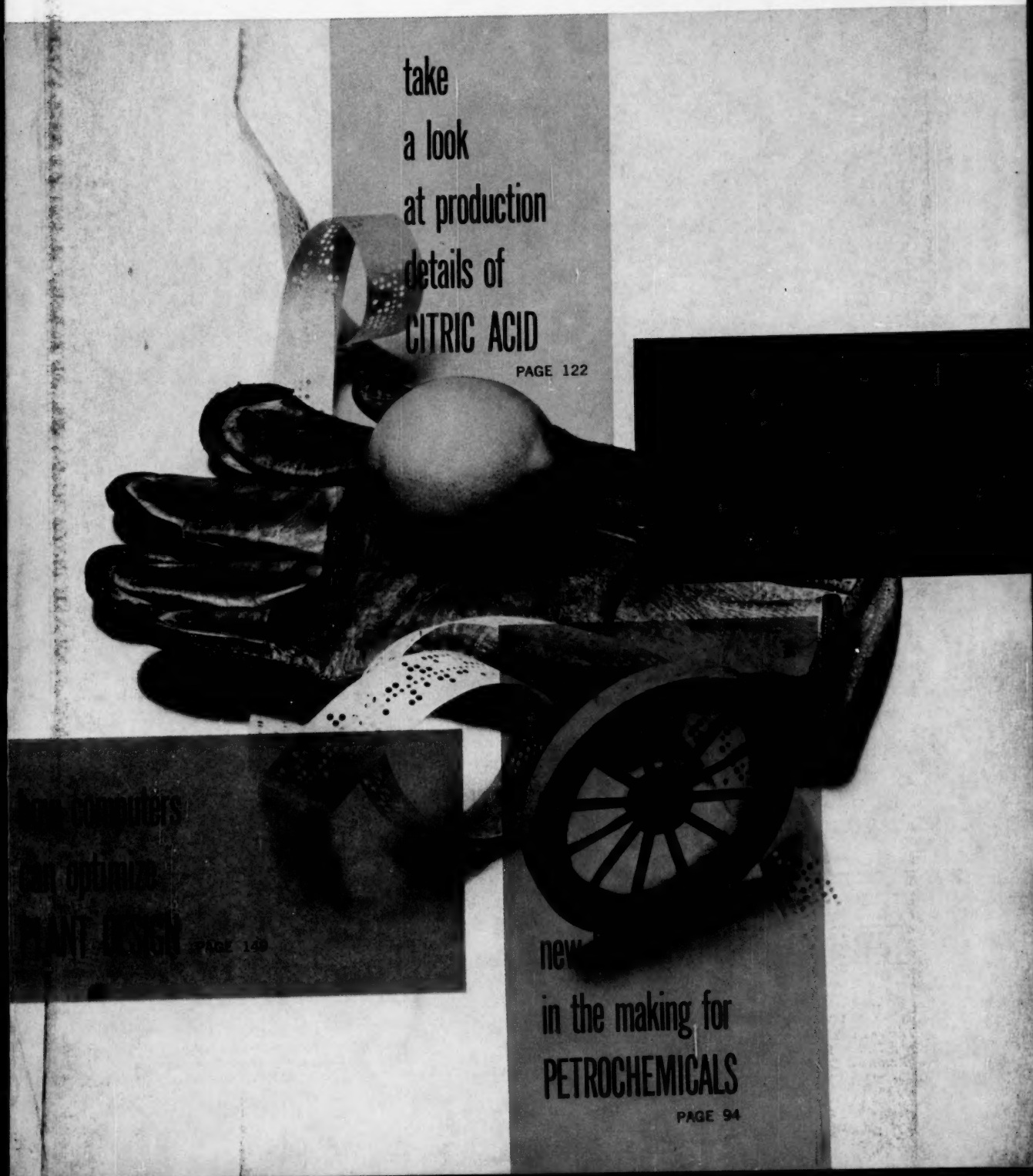
APRIL 3, 1961
Published every-other-Monday
Seventy-five cents

Chemical Engineering

A McGRAW-HILL PUBLICATION

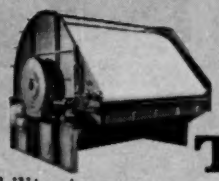


take
a look
at production
details of
CITRIC ACID
PAGE 122

new
in the making for
PETROCHEMICALS
PAGE 94

How EIMCOBELT® Filters

Have E-X-T-E-N-D-E-D the Usefulness of Vacuum Filters



The EimcoBelt filter's ability to remove a continuous belt filter medium from the drum for cake discharge and cloth washing has proved enormously important in the continuous filtration of many difficult slurries.

EimcoBelt continuous belt filters are successfully handling slurries that have always been considered "impossible" for vacuum filtration. Blinding is eliminated with EimcoBelt filters. Every square inch of filter medium is scoured clean with wash sprays, front and back, every filter revolution. Eimco's patented aligning mechanism maintains the filter medium in true alignment without operator attention.

As a result, new savings are now being made in many processing operations . . . savings in downtime and labor . . . reductions in processing costs . . . added profits in increased product recoveries, now possible with EimcoBelt filters.

Ask the Eimco representative in your area how EimcoBelt filters can save processing dollars in your plant. Write Eimco Filter Division for Bulletin FE-2053

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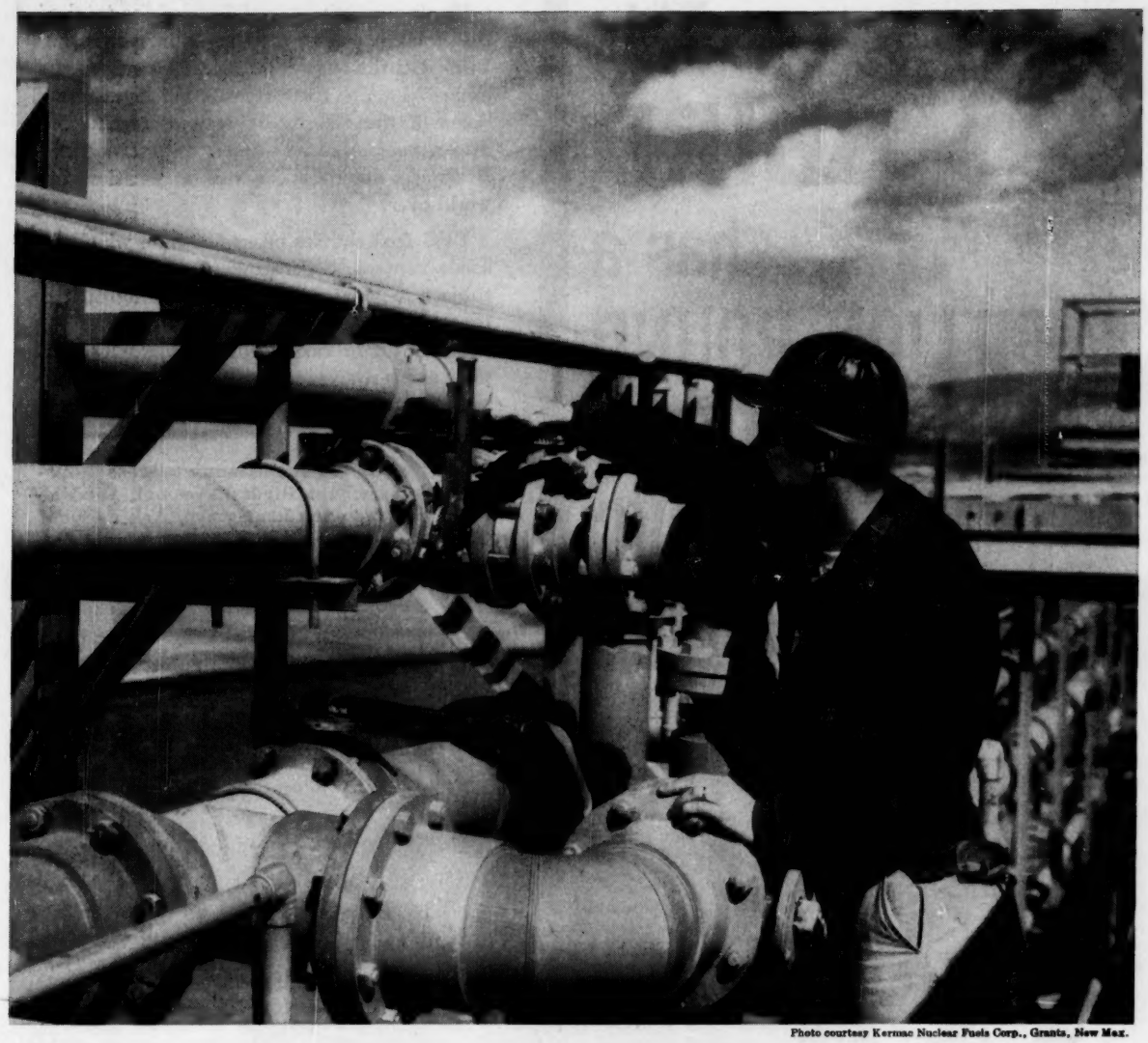


Photo courtesy Kermac Nuclear Fuels Corp., Grants, New Mex.

Imagine a pipe even strongest acids can't ruin

ENGINEERS, designing a huge uranium concentrating plant, needed pipe that could keep highly corrosive mixtures of acids and organic solutions flowing continuously—and virtually automatically — through various processing stages. Metal pipe was out of the question. Too apt to corrode.

The answer: Install pipe made of Koroseal rigid PVC by B.F.Goodrich. Koroseal pipe does not corrode, won't rust, never needs painting. It weighs only ¼ as much as steel, so it can be installed easier, faster.

Construction of the uranium plant called for nearly 4 miles of Koroseal pipe, plus hundreds of fittings and valves—the largest installation of rigid vinyl pipe in the country. After 2 years of round-the-clock service, plant engineers report, "no evidence of failure due to corrosion or abrasion".

More and more companies are finding B.F.Goodrich Koroseal PVC pipe ideal for use wherever chemical resistance, high working pressures, good impact resistance are factors. For the full story on Koroseal's many advantages, get in touch with a BFG distributor or send for a free booklet. *B. F. Goodrich Industrial Products Co., Dept. M-981, Akron 18, Ohio.*

Koroseal—T. M. Reg. U. S. Pat. Off.

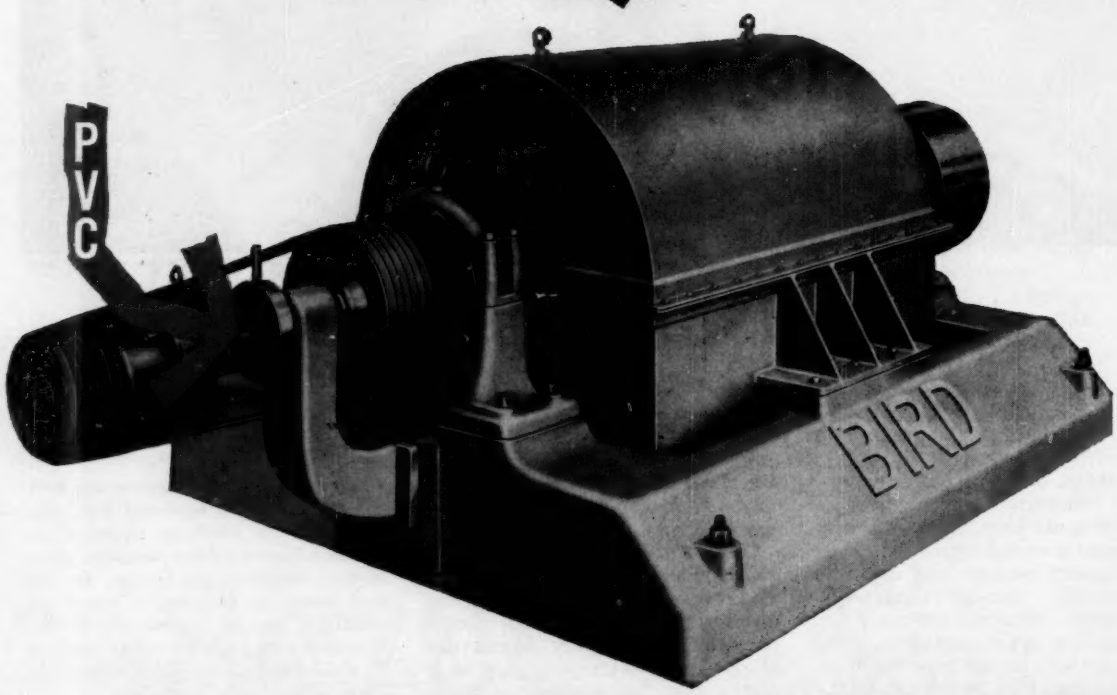
Koroseal rigid PVC products by B.F.Goodrich

This BIRD has a BILLION POUND APPETITE for PVC and PVC COPOLYMERS

Plants producing about 91% of the total of these resins processed in this country are using Bird Continuous Solid Bowl Centrifugals exclusively for their dewatering operations. Some of these Birds have been running for fifteen years. Many represent repeat orders. Birds are standard for this application the world over.

PVC feed slurries often fluctuate widely in solids content. Separating characteristics are subject to great variation, depending on the process. Birds take these variables in stride — effect maximum cake dryness — virtually complete solids recovery. Best of all, operating and maintenance costs are consistently low.

This is but one of many process industries where Birds have multiplied as the industry has grown. Ask us what the Bird Continuous Centrifugal can do to better your solid-liquid separations and reduce their cost. The Bird Research and Development Center is fully equipped to provide pilot-scale test data.



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Chemical Engineering

April 3, 1961

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

PRINT ORDER FOR THIS ISSUE 53,150

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ENGINEERING PRACTICE

OTHER REGULAR FEATURES

VOLUME 68, NUMBER 7

Chemical Engineering (with Chemical & Metallurgical Engineering) is published biweekly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder.

Publication Office: 99-129 North Broadway, Albany 1, N. Y.

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Second class postage paid at Albany, N. Y. Printed in U.S.A.

Subscriptions: Send correspondence and change of address to Fulfillment Manager, Chemical Engineering, 330 West 42nd Street, New York 36, N. Y. Send notice promptly for change of address, giving old as well as new address. Enclose an address label from a recent issue of the magazine if possible. Allow one month for change to become effective.

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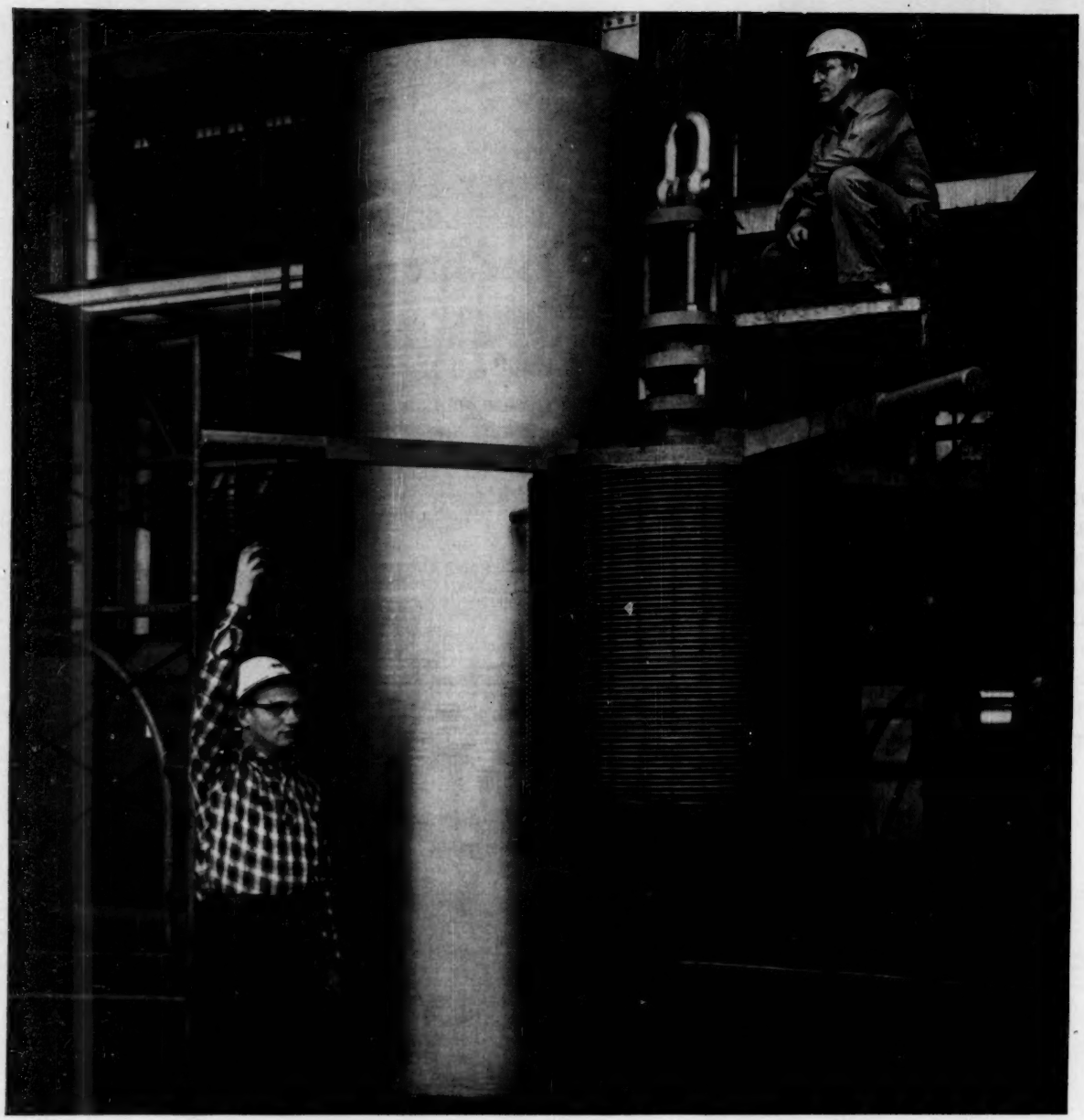

THIS FORGED PRESSURE VESSEL GOT A HYDROSTATIC TEST IN EXCESS OF 70,000 PSI Designed by Harwood Engineering Company, Inc., Walpole, Mass., for Fansteel Metallurgical Corporation, North Chicago, Illinois, this pressure vessel is of two-layer, shrink-fit construction.

The two shells and all the head closure parts were forged by Bethlehem from alloy steel, then heat-treated, finish-machined, and assembled in Bethlehem shops. The vessel measures 122 inches in length and weighs a bit over 30 tons. Diameter inside is 18 inches; outside it's 49½ inches.

Like all Bethlehem forged vessels—whether they tip the scale at 150 tons or 900 pounds—this one is built for long, heavy-duty service. Our technical men will be glad to work closely with you. Once the design is approved, you can count on our shops to follow-through with a first-rate production job.

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Chemical Engineering
APRIL 3, 1961

highlights of this issue

WILL GULF COAST LOSE ITS GRIP ON PETROCHEMICALS?

It could happen, according to speakers at AIChE's recent meeting in New Orleans. Shifting economic patterns will channel future petrochemical growth to the East Coast, they claim (p. 94). This prediction reflects the emergence of transportation costs, rather than costs of raw materials, as the dominant factor in petrochemical site selection.

NEW CONTENDER ENLIVENS CITRIC ACID PICTURE

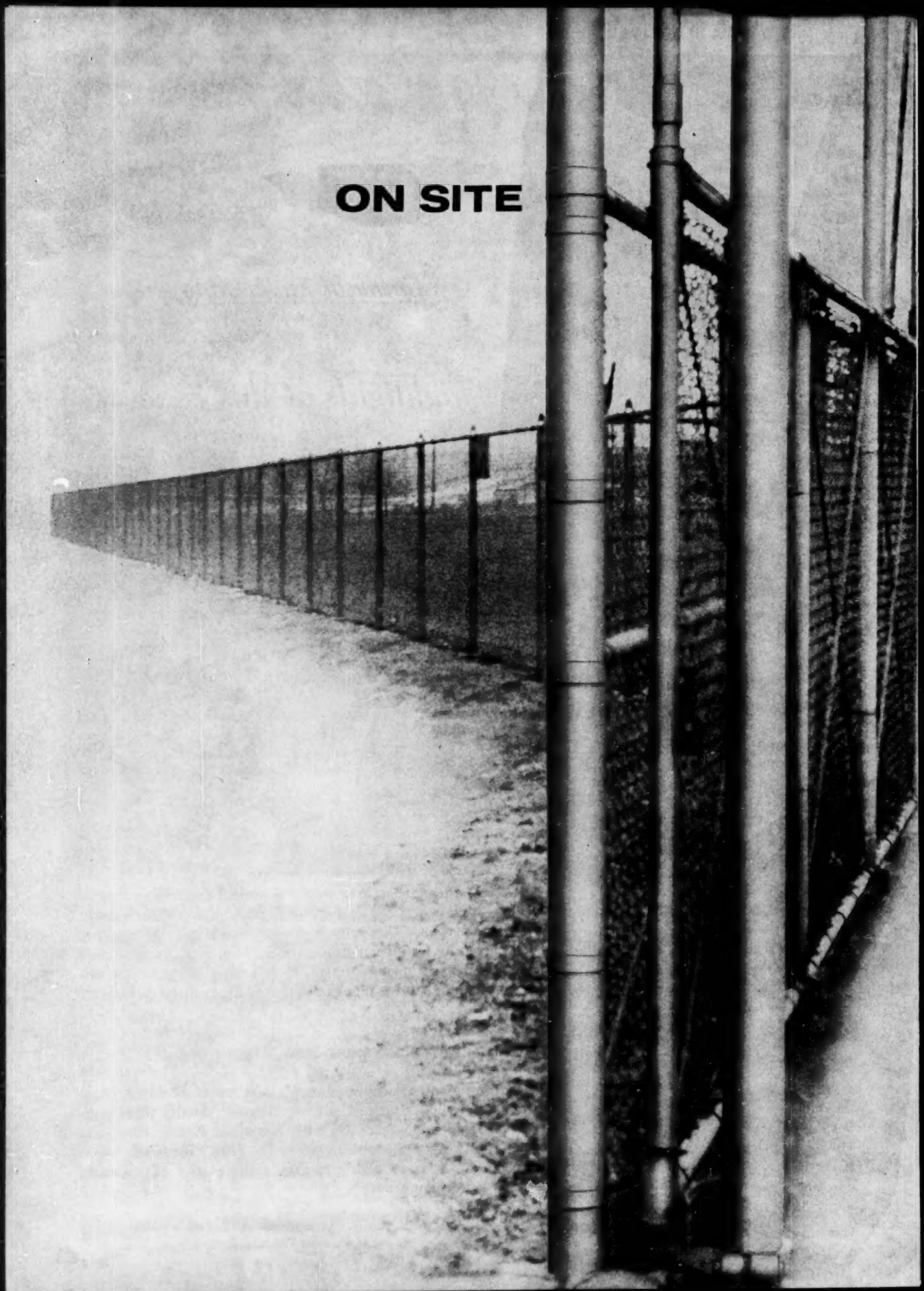
The new entry is Bzura Chemical Co., whose novel operations at Fieldsboro, N. J., are described in our Process Flowsheet (p. 122). Bzura achieves low-cost operation by using blackstrap molasses as its raw material, along with short fermentation cycles.

FOAM SEPARATION SET TO GO

Foam is an anathema to many chemical processing operations—unless you can find a way to make it work for instead of against you. One way is foam separation, a technique developed by Radiation Applications, Inc., and now available for commercial use (p. 100). It will most likely find application where solutes must be removed from dilute solutions.

CONTRACT MAINTENANCE—HOW FAR TO GO?

Mention "contract maintenance" in a crowd of plant engineers and you'll touch off a lively debate. That's what happened in Chicago recently, with Assistant Editor Jim Marshall on the sidelines taking notes (p. 170). He found there were two sides to this question, with plenty of room in between for compromise.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...OR ACROSS THE FENCE

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Buy oxygen as you would buy other chemical commodities—let Airco build and operate a tonnage oxygen plant for you.

Airco will build on your site, or on property we acquire adjacent to your plant. Either way, you are assured of all the oxygen you require . . . at a steady rate . . . at a firm, fair price. And if you have a use for nitrogen in one of your processes, that too is available from the oxygen plant.

Consider the advantages of having Airco supply your oxygen on this basis:

No Capital Investment. Airco finances the oxygen plant, whether it's on property leased from you or on our over-the-fence site. You pay only for oxygen, just as you would for natural gas piped into your plant. The capital required for the oxygen plant is available to you for other ventures.

Proven Technology. Airco draws on more than 40 years' experience in low-temperature technology . . . design, engineering and construction proficiency that has dotted the country with oxygen and other industrial gas plants of all sizes. Our processes are efficient . . . our plants economical . . . our engineers proficient in air separation.

Oxygen Available Fast. Airco has the personnel to bring a plant onstream fast . . . will meet any construction schedule promised.

Assured Low Cost. Industrial gases are our business, so there's no first-plant guesswork on oxygen costs. We give you a firm contractual price that reflects the economies that come with large resources and long experience. Moreover, there may be other, smaller oxygen users in your area. An Airco off-site plant built primarily to supply you would be designed to meet the area requirements, thereby making a lower unit price possible.

Multi-Plant Back-Up: At all times, you are assured of a steady flow of oxygen because your new plant is a part of Airco's integrated system of supply — a nationwide network of oxygen plants.

New Processes Using Oxygen and Nitrogen

Many plants under construction are designed for processes based on tonnage oxygen: partial oxidation of natural gas or fuel oil to produce hydrogen for ammonia and methanol; ethylene oxidation processes; Sachsse acetylene process; oxidation of select hydrocarbons to aldehydes, acids and alcohols. Tonnage nitrogen from such plants is being used increasingly for ammonia synthesis and as a blanketing medium to provide an inert atmosphere.

Whatever oxygen- or nitrogen-using process you are considering, it will pay you to investigate Airco's tonnage products. For complete details, contact Airco.

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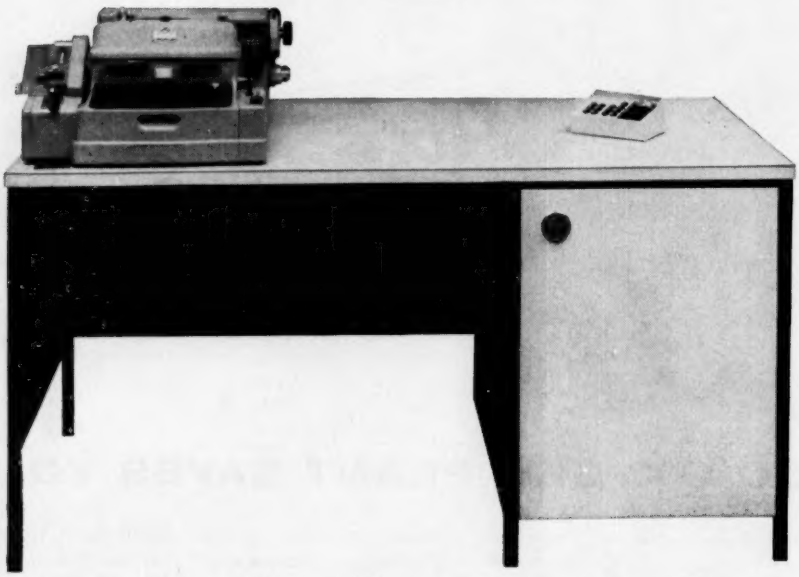

Autonetics, producer of the world's first and finest solid-state, general-purpose, compact digital computer, now introduces a small-scale computer that is priced amazingly low.

It is Recomp III—a general-purpose solid-state digital computer for engineering, scientific, and industrial use.

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Recomp III offers you the largest word size and the largest memory of *any* small-scale computer.

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Now you can get Recomp's proven performance and quality for *no* more than you pay for lesser computers... and it is now available.

If your computer problems have grown and your computer hasn't; if you need a small-scale digital computer; now, for a lease price equal to what you are already paying or would expect to pay for an outdated computer, you can have the newest, most advanced, small-scale computer on the market—Recomp III.

For a convenient do-it-yourself comparison of Recomp III with your present computer or a competitive computer see the following page.

MAKE A POINT-BY-POINT COMPARISON OF YOUR PRESENT COMPUTER OR ANY SMALL-SCALE LOW-PRICED COMPUTER WITH THE NEW RECOMP III

	RECOMP III	COMPETITIVE COMPUTER
Monthly lease price	$1,495.00	$_____
Input Standard	Mechanical Reader	_____
	10 char/sec	_____
	Typewriter Engineering Keyboard	_____
	Typing Speed	_____
	Full Alphanumeric Input	_____
Input Optional	Capacitance Reader	_____
	600 char/sec (stops within a char)	_____
	Up to any type of four inputs	_____
Arithmetic Speeds—Fixed Point		
Add & subtract	.54 milsec (12 digits)	_____
Multiply	10.8 milsec (12 digits)	_____
Divide	11.3 milsec (12 digits)	_____
Access Time—Main Memory—average	9.0 milsec	_____
High Speed Loops—average	1.7 milsec	_____
Arithmetic Speeds—Floating Point		
Add & subtract	.81 milsec (12 digits)	_____
Multiply	8.6 milsec (12 digits)	_____
Divide	8.9 milsec (12 digits)	_____

	RECOMP III	COMPETITIVE COMPUTER
Memory	Disk—Non-volatile	_____
	Capacity 4096 words	_____
	Word size 40 bits & sign	_____
	12 decimal digits	_____
	Command size—2 commands per word	_____
	Instruction capacity 8192 instructions	_____
Programming	Machine language (fixed point) very simple and versatile	_____
	Machine language (floating point) very simple and versatile	_____
Outputs—Standard	Typewriter (alphanumeric engineering keyboard)	_____
	10 char/sec (printing speed)	_____
	Paper Tape Punch	_____
	10 char/sec (punching speed)	_____
Outputs—Optional	Facitape High Speed Punch	_____
	150 char/sec	_____
	Up to four outputs	_____
Characteristics	250 pounds (computer)	_____
	Solid State	_____
	Desk size	_____
Power Requirements	3.5 amps any wall outlet 115 v ac	_____
Heat	No cooling needed	_____

If your computer, or a competitive computer, doesn't measure up to Recomp III, this coupon can save you time and money.

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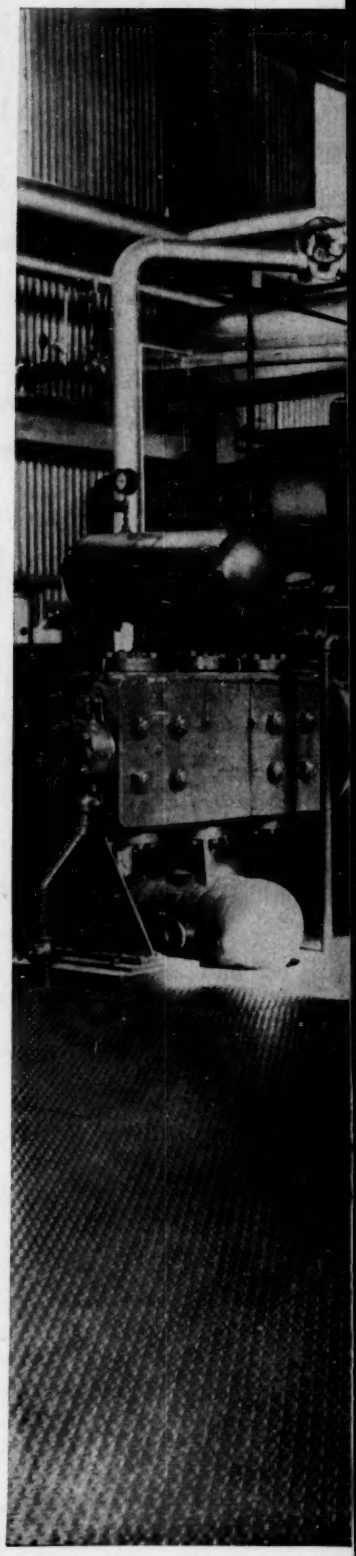
AUTONETICS DIVISION OF NORTH AMERICAN AVIATION, INC.

Noel M. Champion *(left), Chief Engineer, Armour Agricultural Chemical Company, discusses a technical problem with* Robert L. Kietzman, *Sales Engineer, The Cooper-Bessemer Corporation, St. Louis District Office.*



How Cooper-Bessemer service helps keep the ammonia flowing

At Armour Agricultural Chemical Co., Crystal City, Missouri, nine Cooper-Bessemer compressors play key roles in the manufacture of ammonia products. Round the clock, for five years, these units have given exceptional performance under the rigors of such problems as handling pressures up to 9000 psi.

The performance of these C-B compressors has been backed by Cooper-Bessemer engineers in the St. Louis area and in Mt. Vernon, contributing helpful service for these high-pressure operations.

Cooper-Bessemer engineers will gladly help *you* plan compression facilities, and demonstrate how this unique service works for your benefit. Call the nearest office.

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COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
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Noel M. Champion *(left) and* Thomas H. Ferebee, *Supt. Ammonia Plant. In background are two GMWA-10, four GMWA-8 and one GMWA-6 engine driven compressors for compression of air, natural gas, synthesis gas and ammonia. Armour also has two FM compressors for ammonia recirculators.*


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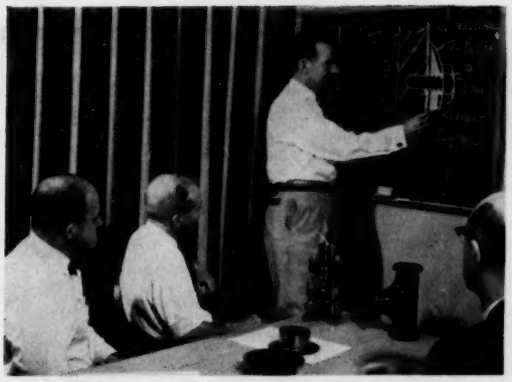
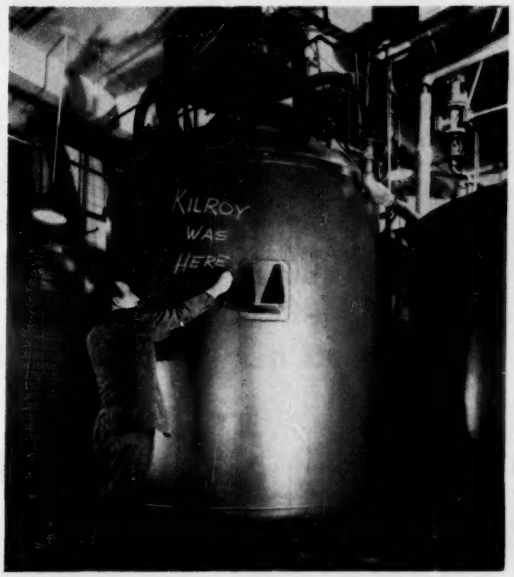
MAKING GLASS-LINED EQUIPMENT LAST LONGER

Nobody makes glass-lined equipment better than Glascote. But to get the most out of any good product — expert installation and maintenance care are vitally important.

You deserve the long-life, trouble-free performance that's built into all Glascote equipment. That's why Glascote has experts like Jack Kilroy at your beck and call. *At your plant* when a reactor is being installed . . . *at your plant* to instruct your men in correct Glascote maintenance procedure . . . *at your plant, and fast,* should any unusual servicing be required. In short, at your service whenever and wherever you need it.



HE MAY BE HERE in your plant, conducting a popular Glascote seminar and training course on the care and maintenance of glass-lined equipment. In fact, Jack Kilroy traveled over 10,000 miles in one busy week assisting processors in maintaining continuous operations.



OR HERE getting you out of a downtime bind. When a leaky gasket caused nozzle trouble, help was needed fast. Kilroy came on the double — actually rebuilt the nozzle right on site. Signed, sealed and repaired on time.

Through research . . . a better way

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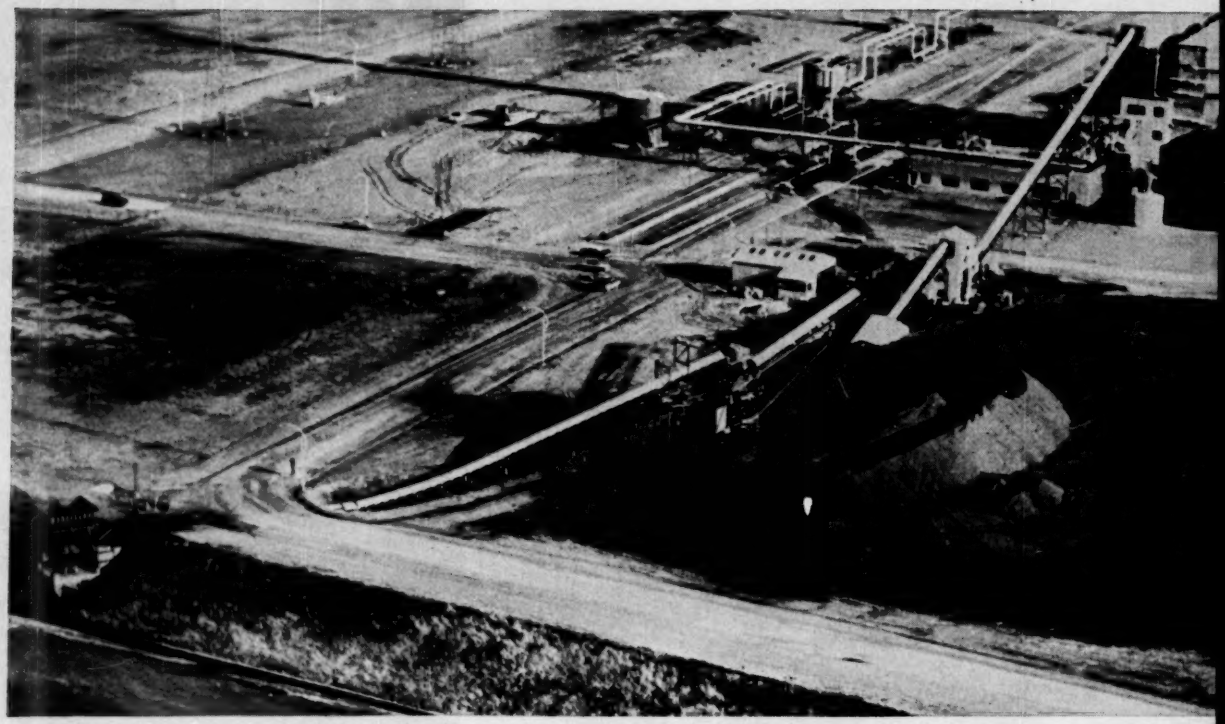

All five units in this stockpiling-reclaiming Barber-Greene belt conveyor system are shown here . . . the unloading conveyor . . . cantilevered radial stacker . . . two reclaiming conveyors . . . and the enclosed conveyor atop bunkers that fills bunkers automatically.

At new Steam Plant in Sarnia, Ontario:

AUTOMATED BARBER-GREENE STOCKPILE

One man controls Canada's highest-capacity steam plant coal handling system

Dow Chemical of Canada, Limited specified and got a stockpiling-reclaiming belt conveyor system as ultra modern as the rest of its new steam plant at Sarnia, Ontario.

Working as a team, Dow Chemical and Barber-Greene engineers designed an automated conveyer system that can stockpile 20,000 tons of coal in eight hours at 2,500 tph. The bunkering conveyor system reclaims, crushes, samples and weighs coal before delivering it to steam plant bunkers at 440 tph.

Self-unloading ships deliver coal to a special dock on St. Clair River and feed it at high speed into a 20′ x 20′ hopper. The hopper feeds a 60″ x 325′ belt conveyor that moves coal at 670 fpm to a cantilevered radial stacker. This special 110′ stacker with 60″ belt stockpiles in a 150° arc.

Material is reclaimed on a 170′ tunnel conveyor under the pile that feeds the crusher. Tramp iron is removed by a magnetic head pulley on the conveyor, and the coal is discharged into the crusher. A 319′ conveyor fed by the crusher moves the coal over an automatic weighing device to a 115′ tripper conveyor that automatically charges the bunkers.

Get the same very special attention for your bulk materials handling problems, no matter how complex or commonplace, by calling in your Barber-Greene Conveyor Representative.

Your belt conveyor equipment headquarters.

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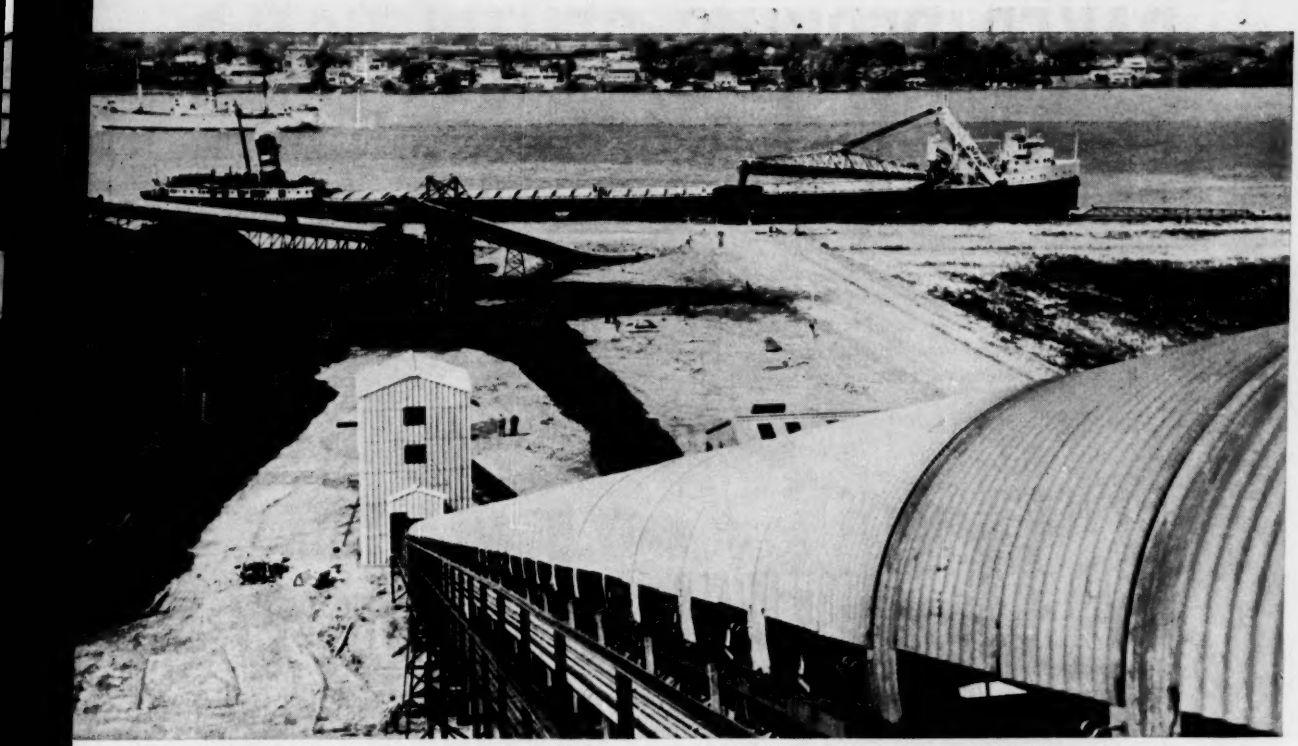
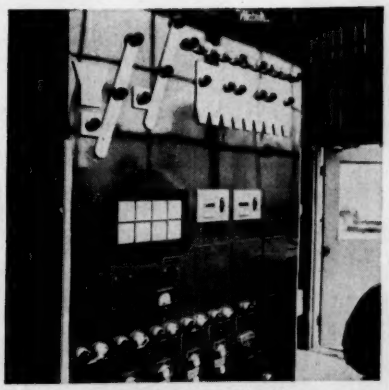
ASPHALT PAVING EQUIPMENT



Huge coal ship spends minimum time at river bank dock because high-speed Barber-Greene stockpiling conveyors can transfer 20,000 tons of coal to stockpile in eight hours. Utilization of many control devices makes system both automatic and safe to operate.

BELT CONVEYORS COAL AT 2,500 T.P.H.

Specially-designed counterweighted radial stacker is supported only at tail end. By means of level indicator and timer, it automatically moves to new position each time coal reaches head of stacker. Both stacker and conveyor feeding it can be stopped from any point by operator. Conveyor system's 800-1,200 hour lube interval minimizes maintenance needs.



Entire operation is automatically controlled from two master control panels. Panel lights indicate operating status of all equipment in system.

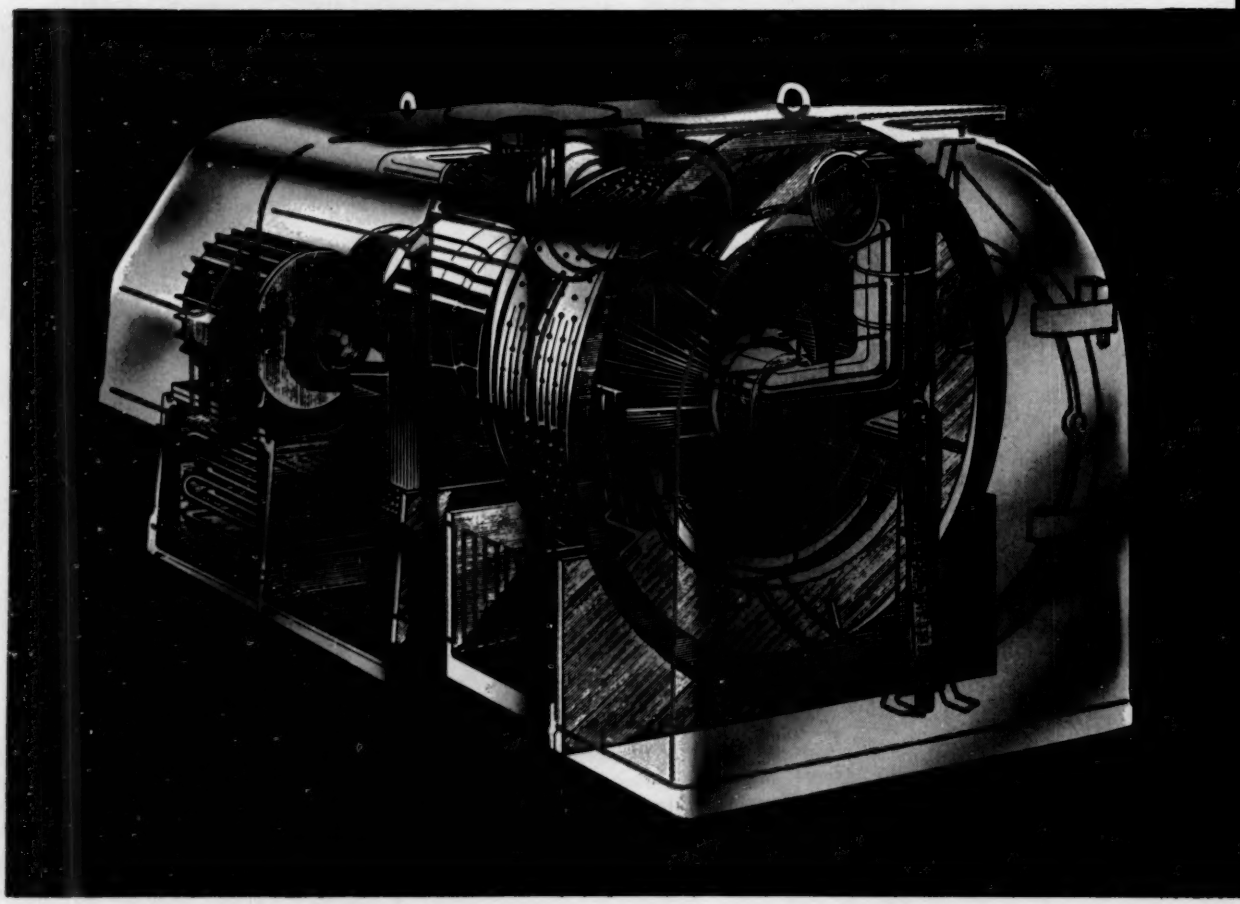
BAKER PERKINS CENTRIFUGALS

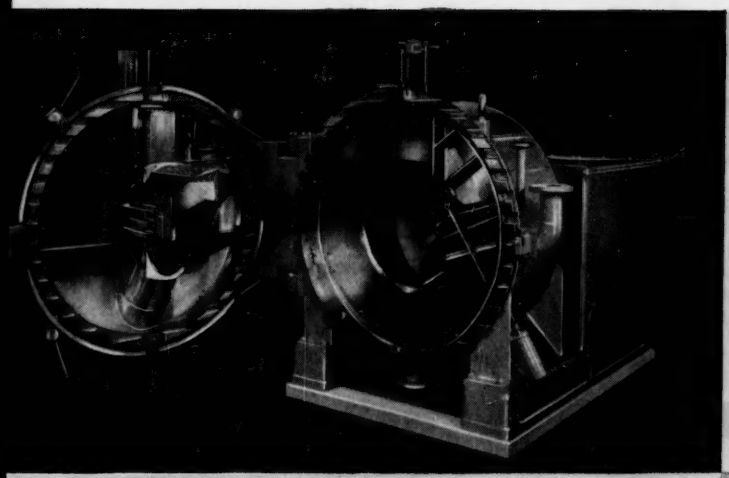
FOR ECONOMICAL SEPARATION OF FILTERABLE SOLIDS

Baker Perkins centrifugals have an enviable reputation for efficiency and economy in centrifugation. The well known Baker Perkins continuous pusher type and automatic universal centrifugals have been used successfully for years to separate many different filterable solids. Now with a multi-stage continuous pusher type centrifugal and an automatic vertical pusher type centrifugal, there is a Baker Perkins centrifugal to separate both slow draining solids and extremely fragile crystals. All Baker Perkins centrifugals are manufactured in many sizes, many different materials of construction and with special design features to meet your process requirements.

B-P (ESCHER-WYSS) MULTI-STAGE CENTRIFUGALS

Continuous centrifugation of difficult-to-handle materials is now possible with new B-P (Escher-Wyss) Multi-Stage Continuous Centrifugals. The continuous multi-stage pusher centrifugal eliminates cake buckling, assures adequate retention time, speeds release of liquids, improves washing, provides better separation of multiple liquid components and reduces power consumption. Models are available with capacities from 1½ tons to 45 tons per hour.



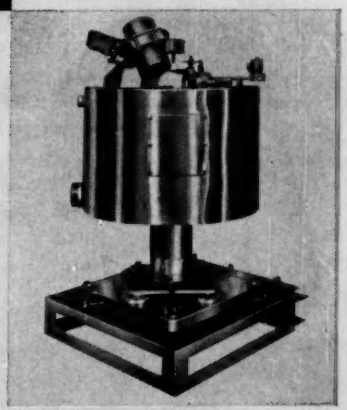


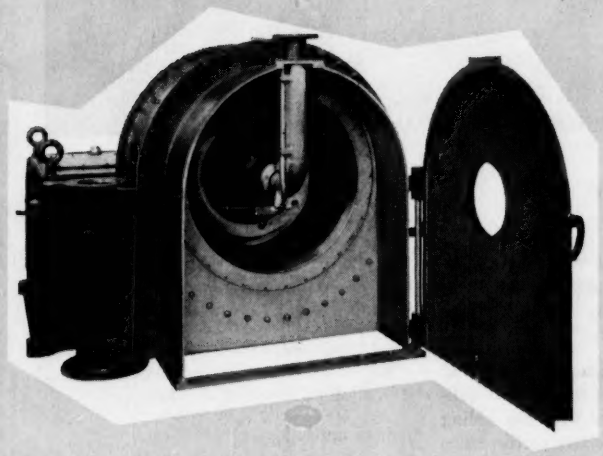
PRESSURE CENTRIFUGALS

The B-P HS 40W is one of a line of pressure centrifugals built for normal operation at 1000 times gravity and pressures up to 150 PSIG. Many new features include: a self-seating, self-aligning door seal, housings that withstand extreme operating pressures, new type discharge knife and chute, and a peeler knife that enters the cake at successively increasing depths, thus eliminating cake glazing.

VERTICAL CENTRIFUGALS

The new Baker Perkins VS-20 Vertical Centrifugal is designed and built to handle friable crystals during charging without danger of crystal degradation. The unit is charged with slurries while running at reduced speeds, then automatically accelerates for the drying and washing operations and automatically decelerates for discharge.



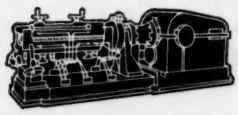


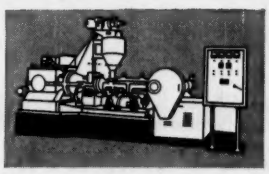
CONTINUOUS CENTRIFUGALS

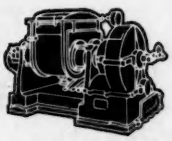
The B-P Type S Centrifugal has continuous feed and discharge requiring no timing or cycle controllers. It is ideal for centrifuging a wide range of relatively free-draining crystalline materials. Friable solids are handled easily since there are no scrapers, baffles, rakes or plows to cause crystal degradation. Models are available with capacities up to 54 tons per hour of solids.

403

BAKER PERKINS INC.





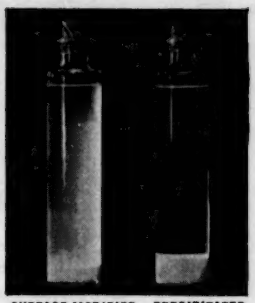


CONTINUOUS MIXERS • PLASTICS MACHINERY • UNIVERSAL MIXERS

SAGINAW, MICHIGAN

Modified ASP's Now Solving Problems in Organic Systems

Aluminum Silicate Pigments, always associated with aqueous systems, now can be provided as organophillic ingredients . . . worth looking into . . . use the coupon.



SURFACE MODIFIED ASP — PRECIPITATED $CaCO_3$

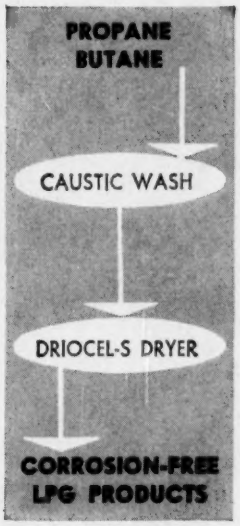
Vehicle: Mineral Spirits
Settling Time: 30 minutes

MCP PROCESS MATERIALS

Drying Hydrocarbons?

Low-cost, Long-life DRIOCEL S Desiccant Gives Corrosion-free Final Products

DRIOCEL-S is MCP's special activated bauxite drying agent for overcoming souring of hydrocarbon liquids such as LPG products in the final drying step. This unique desiccant produces a sweet, non - corrosive, thoroughly dried product with no polymerization of unsaturates. Working samples of DRIOCEL -S and complete technical data sent promptly . . . use the coupon.



Weed-Free Crops

Without Cultivation With Granular Herbicides

Chemical treatment again replaces labor with granular pre-emergence herbicides. They are selective. The desired crop grows. The weeds do not. From wide experimentation with application methods, the use of granular formulations has gained the widest acceptance. They have the advantage of:

results obtained at *lower cost*
easier to produce, package, store, handle
no drift in application
flexibility in application methods

MCP's GRANULAR ATTACLAY, available in a variety of mesh sizes, is the most widely used carrier material for herbicides . . . look into these versatile, highly absorbent carriers for your product . . . TI-153 has all the facts . . . use the coupon.

MINERALS & CHEMICALS PHILIPP CORP.
8649 Essex Turnpike, Menlo Park, N. J.

I'm Interested In:

☐ Hiding Power in Latex Paints ☐ Organophillic ASP's
☐ Granular Carriers ☐ Dessicant Drying with DRIOCEL-S

Please send, without obligation:

☐ data ☐ samples ☐ prices ☐ technical representative

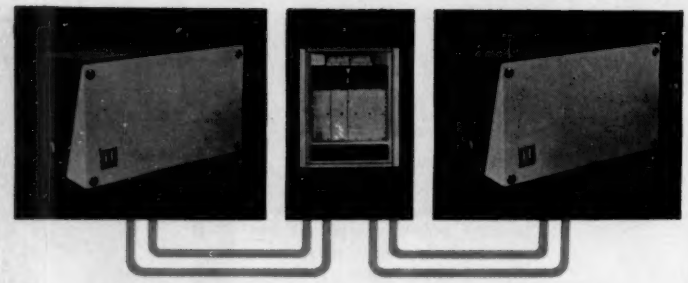
Name _____
Title _____
Company _____
Address _____
City _____ Zone ____ State _____

Use this quick two-check coupon to . . .

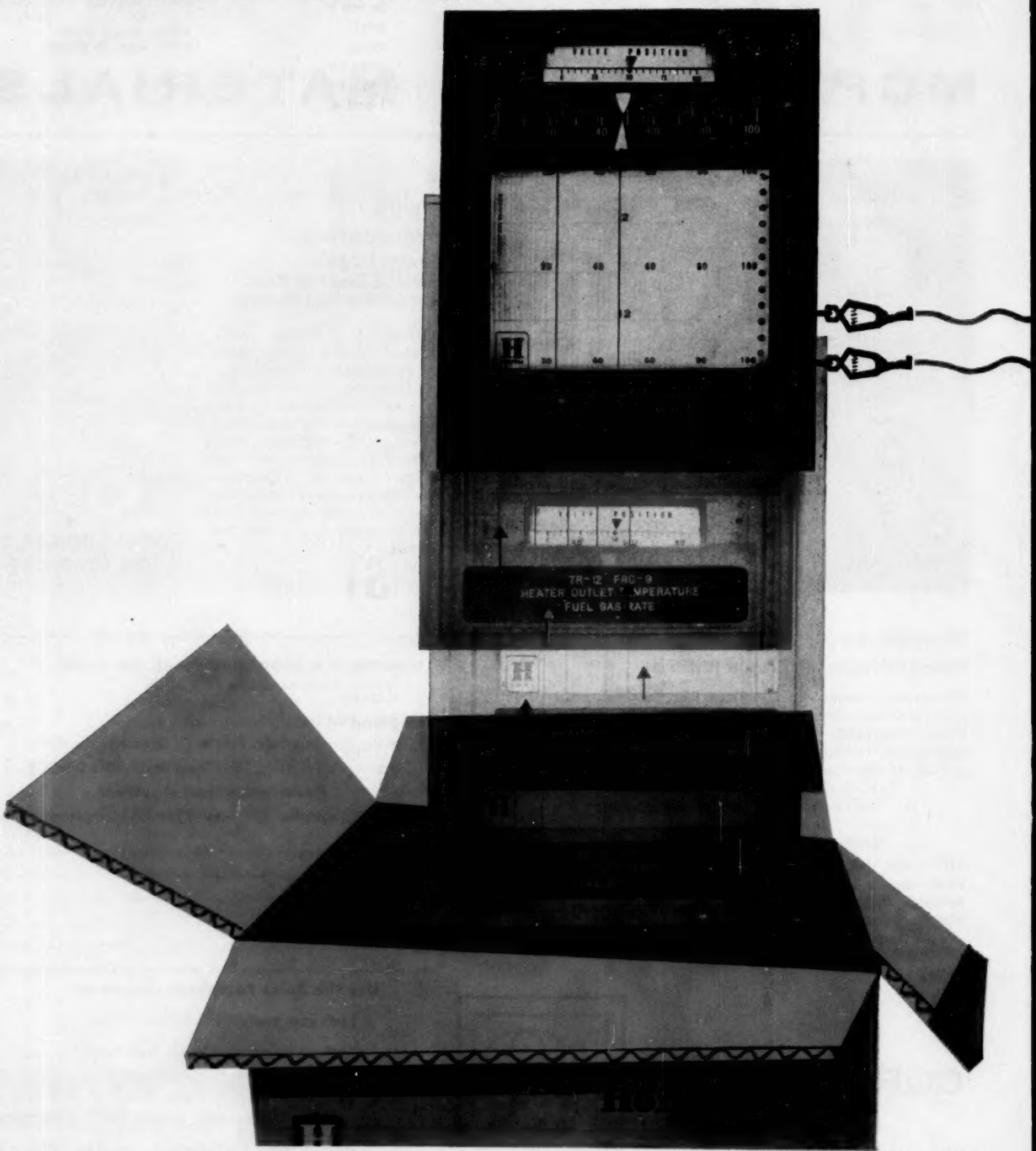
✔ your product interest . . .
✔ what you need to get tests started . . .
we'll fill your requests immediately

CORPORATION

For more data, see your 1961 Chemical Materials Catalogue, pages 423-430



***ElectriK Tel-O-Set*—the true 2-wire system**



This "Loop Snooper" adds to the extraordinary ease of installation and maintenance you'll find in the *ElectriK Tel-O-Set* System. It's a portable test instrument that can accurately check . . . from the control panel . . . any *Tel-O-Set* unit in the field, to make sure signals are being received and sent exactly as they should be. Or it can operate and check a recorder chassis, indicator chassis or controller on the bench, with local power. The "Loop Snooper" removes trial and error from installation and maintenance.

SIMPLEST TO INSTALL, ADJUST AND MAINTAIN

The *ElectriK Tel-O-Set* System has many features that save time in getting on stream, and keep maintenance to a minimum. For example, all process connections are isolated from the inside of *Tel-O-Set* transmitter and transducer cases, so that you can mount, pipe and wire the instruments without removing their covers. Instrument chassis can be removed for servicing without breaking any external process or electrical connections. Standardized parts and extensive use of quick-connect and plug-in design cut downtime and spare parts requirements.

No external power is required at any field-mounted *Tel-O-Set* instrument; line power is connected only at the receiver. Two-wire d-c transmission eliminates shielding and further reduces installation costs. The 4-20 milliamp signal range gives a *live* zero through the use of readily available reliable transistors.

Your nearby Honeywell field engineer can tell you how *ElectriK Tel-O-Set* advantages relate to your particular control requirements. Call him today . . . he's as near as your phone. Or write to MINNEAPOLIS-HONEYWELL, 21 Penn Street, Fall River, Massachusetts.

Honeywell

First in Control

SINCE 1885

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

After three years of thorough research and testing...

RUST-PROOF ONE-PIECE FORGING
Enables downstream line to be removed with valve under pressure without adding extra parts.

CLAYTON MARK
ANNOUNCES THE NEW
Petro® Ball Valve

From a famous family of unions and fittings comes the Petro Ball Valve—a new departure in smooth, effortless, positive sealing that combines basic improvements with unique new developments that only years of research and testing by Clayton Mark engineers could achieve. A new departure, because Clayton Mark literally started where the others left off. *For example*—Clayton Mark Engineers found that nuts and bolts were, and still are, needed to install and repair ball valves. They eliminated this necessity with the union-end assembly feature to provide faster, easier installation and maintenance. *For example*—they also found that a way to reduce pressure drop is needed. Clayton Mark engineers incorporated the largest port opening of any ball valve to assure virtually no pressure drop.

These are just a few of the advances resulting from extensive testing that started with the premise that all ball valves are good—and proceeded from there to develop a ball valve without equal. The new Petro Ball Valve in Stainless Steel, Carbon Steel, and Brass is the result. And remember—*each and every Petro Ball Valve is air tested as it leaves the production line to assure perfect operation.* Write for complete information.

LARGEST PORT OPENING
Largest port opening of any ball valve assures virtually no pressure drop through valve. Hard chrome-plated ball — no metal-to-metal contact assures longer life.

CLAYTON MARK & COMPANY
1900 Dempster Street • Evanston, Illinois

PUMPS · WATER WELL SUPPLIES · CONDUIT · UNIONS · TUBING

The Clayton Mark Petro Ball Valve has been tested over 250,000 turns under MAXIMUM PRESSURE CONDITIONS without failure.

1505

CADMIUM PLATED NUTS

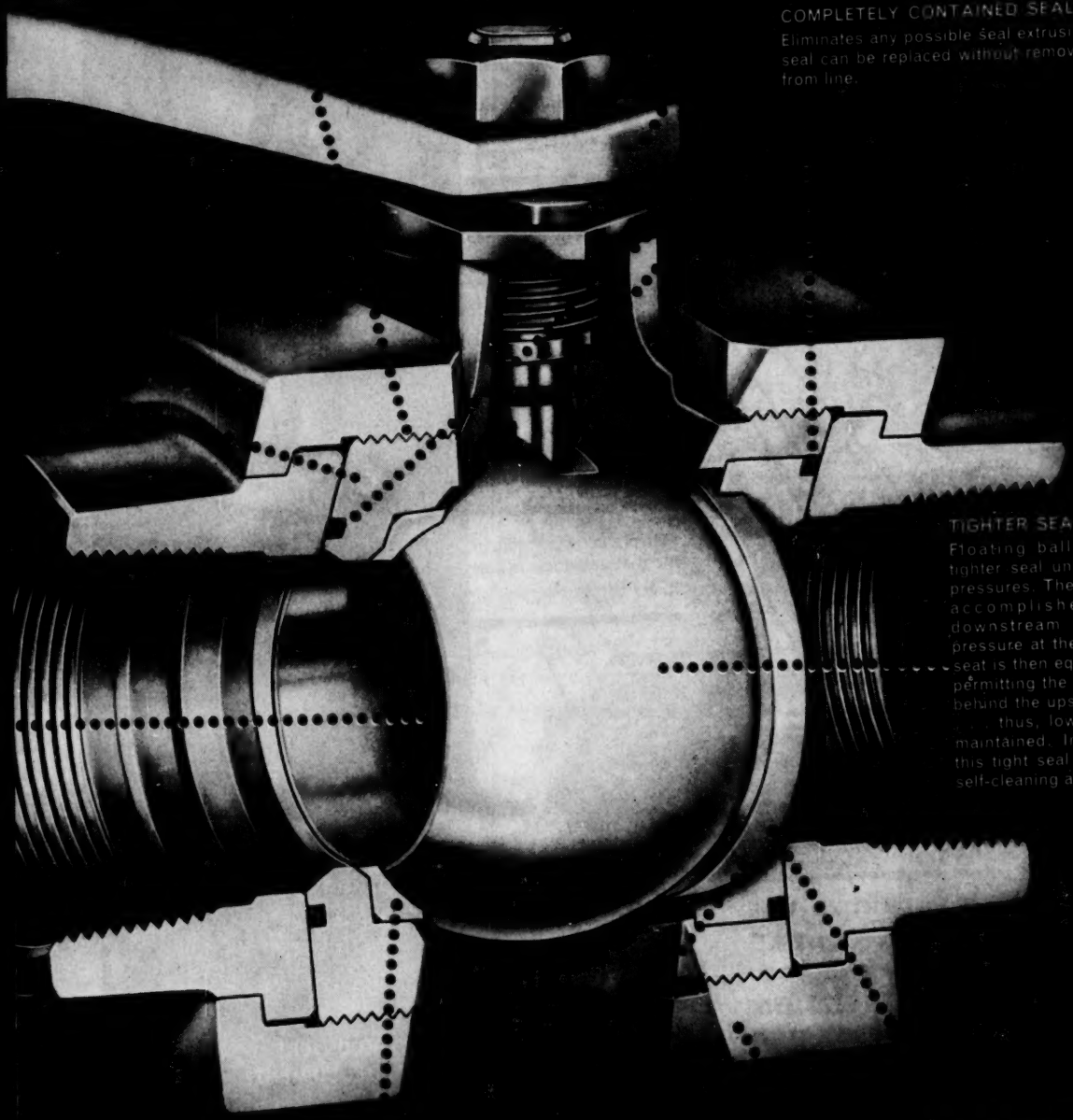
Extra feature that acts as a permanent lubricant for threads and male end shoulder. With this ferrous-to-non-ferrous contact, making and breaking of the connection is easier and safer.

IMPROVED HANDLE

Quick, quarter-turn to full open or closed position. Arrow end of handle indicates opened or closed condition. Handle can be operated in any quadrant and reversible design permits use upside down where space limitations are critical. Rugged malleable iron handle is designed for strength and contoured for comfort.

COMPLETELY CONTAINED SEALS

Eliminates any possible seal extrusion. Stem seal can be replaced without removing body from line.



TIGHTER SEAL

Floating ball assures tighter seal under higher pressures. The sealing is accomplished at the downstream seat. The pressure at the upstream seat is then equalized, by permitting the fluid to get behind the upstream seat . . . thus, low torque is maintained. In addition, this tight seal provides a self-cleaning action.

INTERCHANGEABLE SEATS

Are available in a variety of materials to meet most media problems.

UNIQUE UNION-END INSTALLATION

Union ends eliminate use of nuts and bolts for faster, easier installation and disassembly for maintenance. Also permits maximum pipe misalignment without effecting sealing characteristics, permits valve body rotation under pressure, and allows for complete removal of valve body without disturbing piping installation . . . thereby eliminates any need for additional union.

DUAL SEATS

Permit sealing regardless of direction of flow, and provide check valve feature where back flow is a problem.

NEW CHIKSAN SPRING BALANCED LOADING ARM–

Self compensating spring tension provides complete balance at any position, regardless of position of outer leg. Tension is adjustable if required.

Steel arm is built to take constant use and handling. Top quality components and fabrication mean years of trouble-free service.

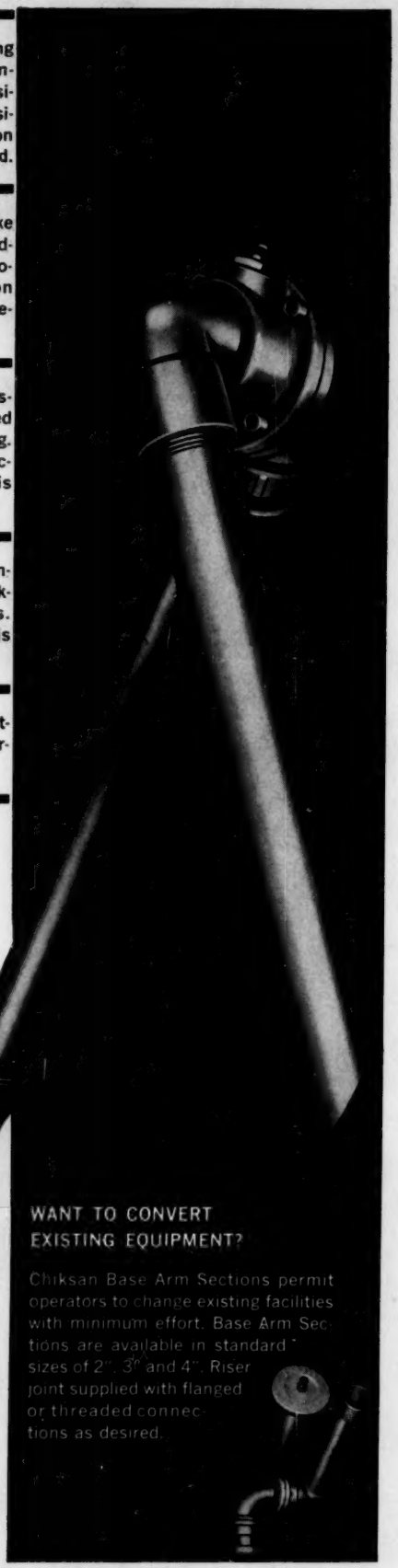
Compression spring assembly is fully contained in strong steel housing. Disassembly for inspection and servicing is readily accomplished.

Compact design. No dangerous protruding brackets or counterweights. Catwalk behind arm is free of obstructions.

Full pre-set stop adjustment at any angle in vertical plane.

FEATURING THE REMARKABLE TOTALLY ENCLOSED COMPRESSION SPRING DESIGN

The Chiksan Spring Balanced arm can be readily installed in any existing terminal. Also, the arm can be modified in the field when more length or equipment is added to it, by the addition of more springs.



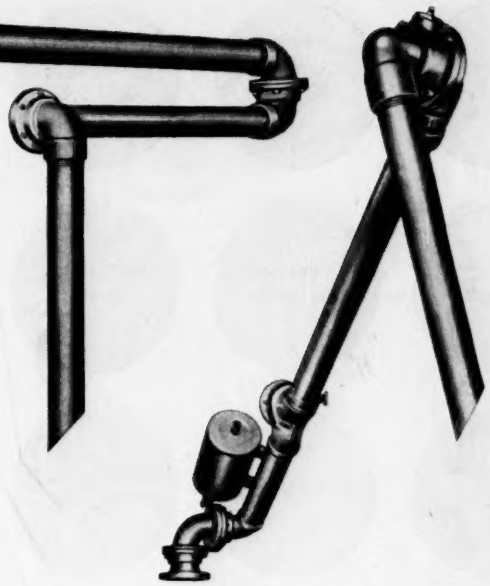
WANT TO CONVERT EXISTING EQUIPMENT?

Chiksan Base Arm Sections permit operators to change existing facilities with minimum effort. Base Arm Sections are available in standard sizes of 2", 3" and 4". Riser joint supplied with flanged or threaded connections as desired.

FOLDED ARM MODEL-DS

Standard Sizes: 2", 3", 4". This quality, heavy-duty arm for hard-to-handle chemicals features the versatile DS Series Swivel Joint described below. The swivel joint combination allows for reach to any point within working range from a minimum of 3-feet from riser pipe to a maximum of 11-feet in the two and three-inch arm and 9-feet in the four-inch arm.

EFFECT FAST, SAFE HANDLING OF CHEMICALS AT YOUR LOADING TERMINALS

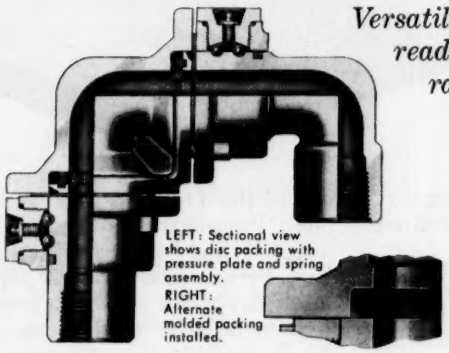


SLIDING SLEEVE MODEL-DS

Standard Sizes: 2", 3", 4". The sliding sleeve Chiksan arm for chemical service employs two DS swivel joints, one on the riser, the other at the drop pipe. The sliding sleeve is of aluminum and bronze construction with an asbestos seal. (Viton and teflon seals are also available.)

FOR TRUCK OR TANK CAR LOADING—

Here's a series of loading arms that measures up on every count. Check payout time. The Chiksan chemical service arms score excellent on minimum maintenance and long service life with little replacement attention. Check operating ease. There's finger-weight flexibility and the arm stays put during adjustment—doesn't creep or sag. Check versatility. With the DS series swivel joint you can, with proper packing, handle virtually any chemical your plant processes or ships. And when it comes to safety, the Chiksan chemical service loading arm has an unbeatable record. Get the facts. Write Chiksan for Bulletin 1-61.



LEFT: Sectional view shows disc packing with pressure plate and spring assembly.
RIGHT: Alternate molded packing installed.

Versatile DS Series Swivel Joint readily adapted to a wide range of services...

There is a Chiksan packing type and compound for handling nearly every chemical in commercial use, also steam and hot gas as well. Further, the DS Series Joint permits packing replacement without removal of ball bearings.

HANDLING PETROLEUM PRODUCTS?

For petroleum service, Chiksan offers you a complete line of spring balanced arms. Choose between the Folded Arm (shown above) or a Sliding Sleeve. Long Reach and Bottom Loader models too. Bulletin 1-61 contains full descriptions. Send for your copy now.

FOR COMPLETE INFORMATION MAIL COUPON TODAY

CHIKSAN COMPANY, 330 North Brea Blvd., Brea, California

Please send me copy of Bulletin No. 1-61.

Name _____

Company _____ Title _____

Address _____

City _____ Zone _____ State _____

CHIKSAN fmc

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

61-62

CHIKSAN COMPANY—General Offices: Brea, California • Well Equipment Mfg. Corp. Division (Weco Unions, Hamer Valves) • Chiksan International • Chiksan of Canada Ltd.
Offices and Representatives in Principal Cities of the World

NOW OPTIMUM INTERCHANGEABILITY IN CHEMICAL PROCESS PUMPS

Simplify process engineering . . . cut parts inventories with this one basic design!

Pinched for process design time? Bugged by corrosive, pressure and temperature problems with pumps?

Solve all these, and other modern pumping problems with this new concept in pump design. It's a back pull-out, horizontal, single-stage, end suction centrifugal. The Model 3195 makes process engineering easier . . . keeps pumping cost low because it gives you:

Maximum interchangeability. The Model 3195 gives you the greatest range of coverage and flexibility—with minimum parts needed—of any line on the market.

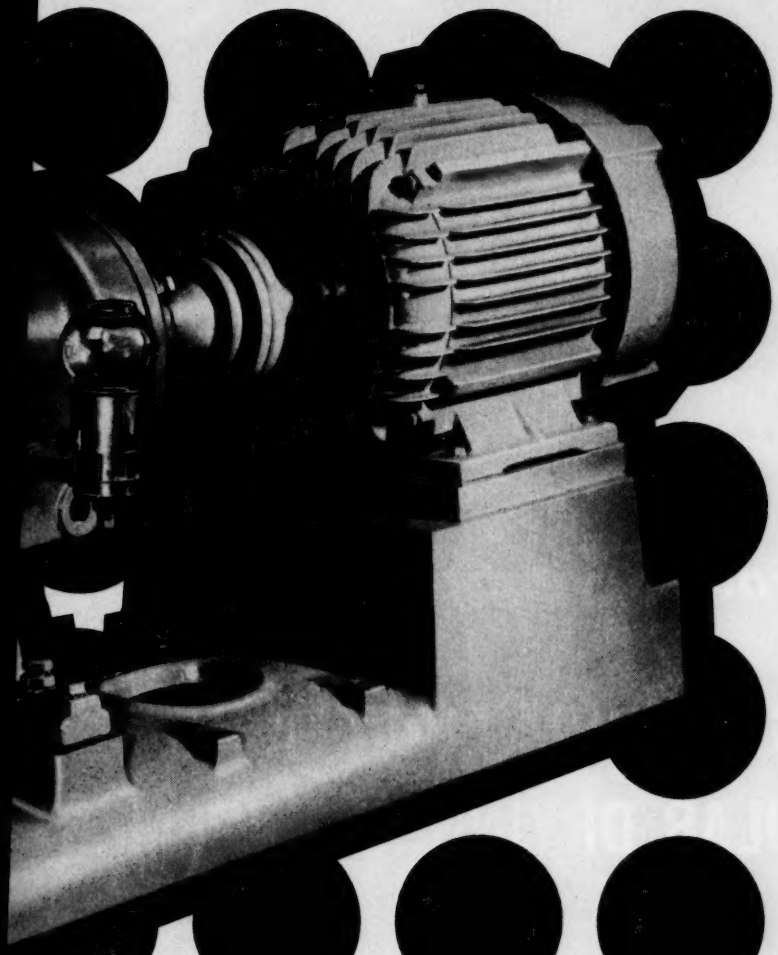
For example, you can mount any one of the 11 pump ends to any one of three bearing frames (shafts 1¼, 1¾, and 2⅛ through stuffing box). Service conditions will determine your choice of bearing frame.

Nominal impeller diameters of 6", 8", and 11" cover the range of the Model 3195 line.

The diagram at right shows you dimensional interchangeability of the units themselves.

Easier maintenance. Back pull-out design, one of a number of easier maintenance features, lets your men replace parts without disturbing piping connections or motor mounting.

Mechanical reliability. Shaft deflection less than .002" at stuffing box face. Two-year minimum bear-

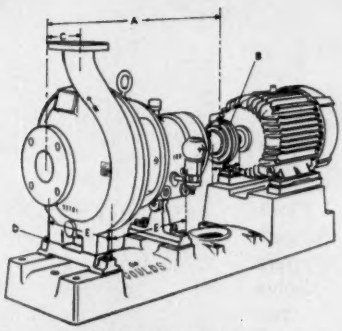


ing life. Dowelled construction provides exact parts alignment.

Full-range coverage.

Capacities . . . . . 5 to 775 GPM
Head . . . . . 10 to 300 ft. TDH
Temperature . . −350° to +500° F
Working Pressure
0 PSIA to 275 PSIG

Cost-conscious materials. You can get any pump in the line **off the shelf** in any of these standard constructions: ductile iron, 316 stainless steel, Gould-A-Loy 20. It is also available in any machinable alloy.



Dimensional Interchangeability Between All Model 3195 Pumps

A One over-all length in all sizes . . 23"
B One coupling fit for all sizes . . . 1⅛"
C One dimension end of suction to centerline of discharge . . . . . 4"
D One bolt size for holding pumps to bases . . . . . ½"
E One bolt spacing for holding all pumps to bases
F One spacer coupling length for all sizes . . . . . 3½"

GOULDS PUMPS

GOULDS PUMPS, INC.
Dept. CE-41,
Seneca Falls, New York

Please send me bulletin on Goulds Model 3195 Chemical Process Pump, showing interchangeability, dimensions and curves.

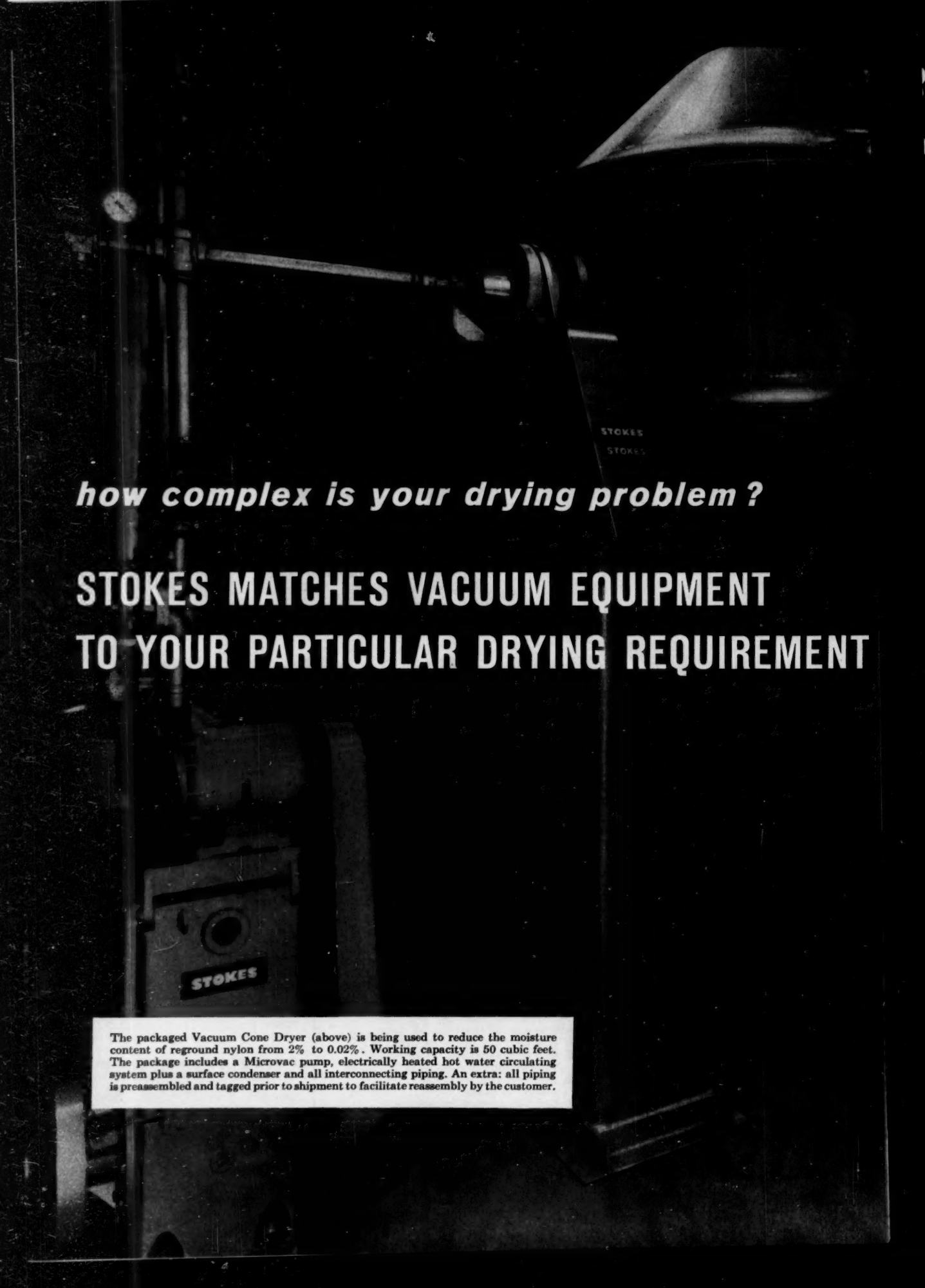
Name.....

Company.....

Street.....

City.....Zone.....

County.....State.....

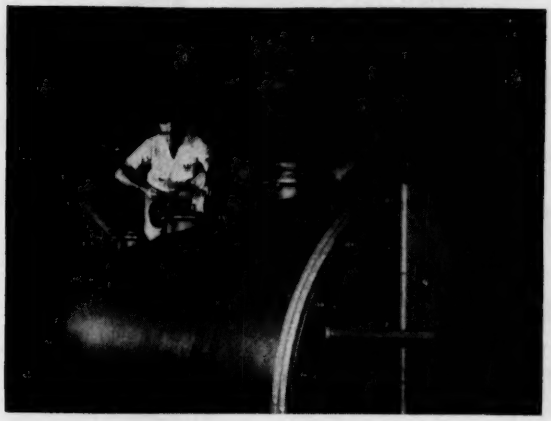


how complex is your drying problem?

STOKES MATCHES VACUUM EQUIPMENT TO YOUR PARTICULAR DRYING REQUIREMENT

The packaged Vacuum Cone Dryer (above) is being used to reduce the moisture content of reground nylon from 2% to 0.02%. Working capacity is 50 cubic feet. The package includes a Microvac pump, electrically heated hot water circulating system plus a surface condenser and all interconnecting piping. An extra: all piping is preassembled and tagged prior to shipment to facilitate reassembly by the customer.

The rotary vacuum dryer shown here is drying tonnage quantities of a chemical salt. This type of dryer is ideal for drying such critical materials as dyes, flocculants, fungicides, insecticides plus organic and inorganic salts. Stokes manufactures a complete line of vacuum drying equipment.



Processing tonnage quantities of materials in an inadequate vacuum dryer can be time consuming and costly. That's why Stokes experienced vacuum engineers study each drying requirement individually . . . then design the drying system to meet your specific needs. Drying systems in capacities from a few pounds to several tons are available . . . along with application engineering, laboratory service and pilot plant operations. Stokes puts its 50 years of vacuum processing experience to work on every drying problem . . . bringing you both money-saving and quality results. What's more, Stokes manufactures all of its own pumps and accessories to assure you one-manufacturer responsibility in addition to unparalleled vacuum know-how.

Stokes will thoroughly explore your production problems . . . make recommendations on the basis of a practical knowledge of process operations . . . and confirm the recommended equipment by actual pilot plant production in the Stokes laboratory, if necessary.

Our representative in your area will initiate Stokes action to assure the best answer to your drying problem. Why not call him soon? And be sure to write for new booklet, "Handy Guide to Vacuum Dryer Selection."

STOKES

Vacuum Process Division

F. J. STOKES CORPORATION

5500 Tabor Road, Philadelphia 20, Pa.

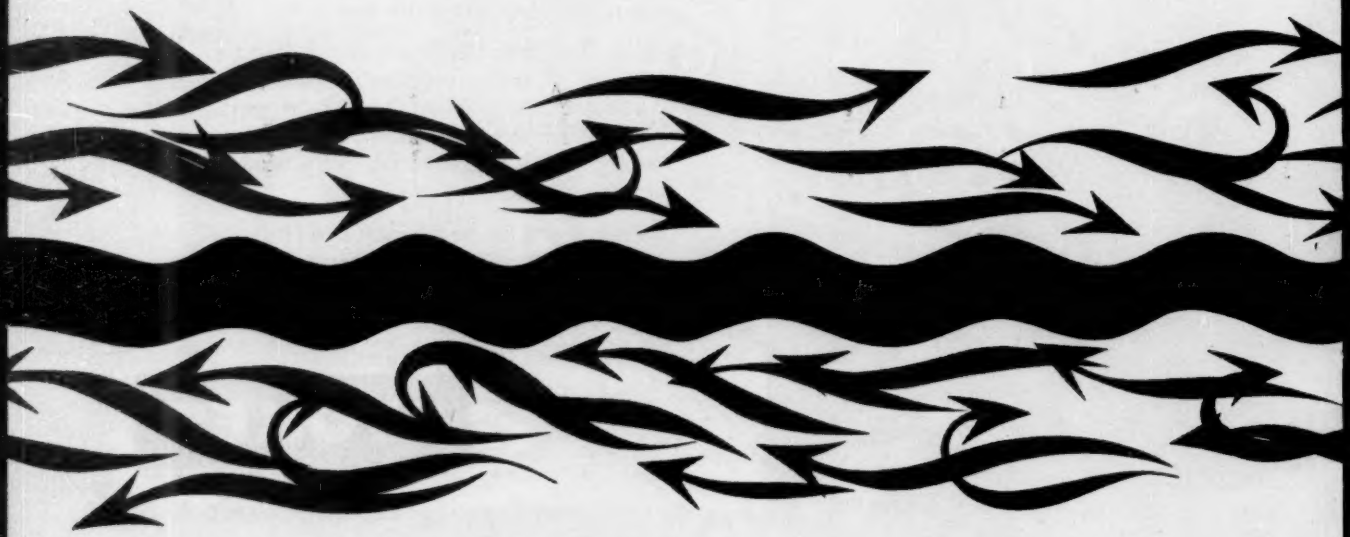
Turbulent liquid layers give remarkable heat transfer in DE LAVAL PLATE HEAT EXCHANGERS

In the past five years, plate heat exchangers have been rapidly outgrowing the limitations of earlier "special" all-stainless applications to become a common replacement for shell and tube units. Extreme compactness, high transfer efficiency, flexibility and trouble-free maintenance have justified this widening use. Installation requires only piping connections.

The benefits of De Laval Plate Heat Exchangers are highlighted here—but you will want to review our "case history" brochure detailing actual processing applications. Write for it, and for our catalog which describes models ranging from 500 to 500,000 lbs/hr capacity.

3 DEGREES OF ECONOMY
open new process possibilities

When the equipment must be all-stainless: At as little as one-third of the cost, including installation, De Laval PHE's do the job better than stainless shell and tubes. Most important, these lower costs and higher efficiencies now permit heat recovery



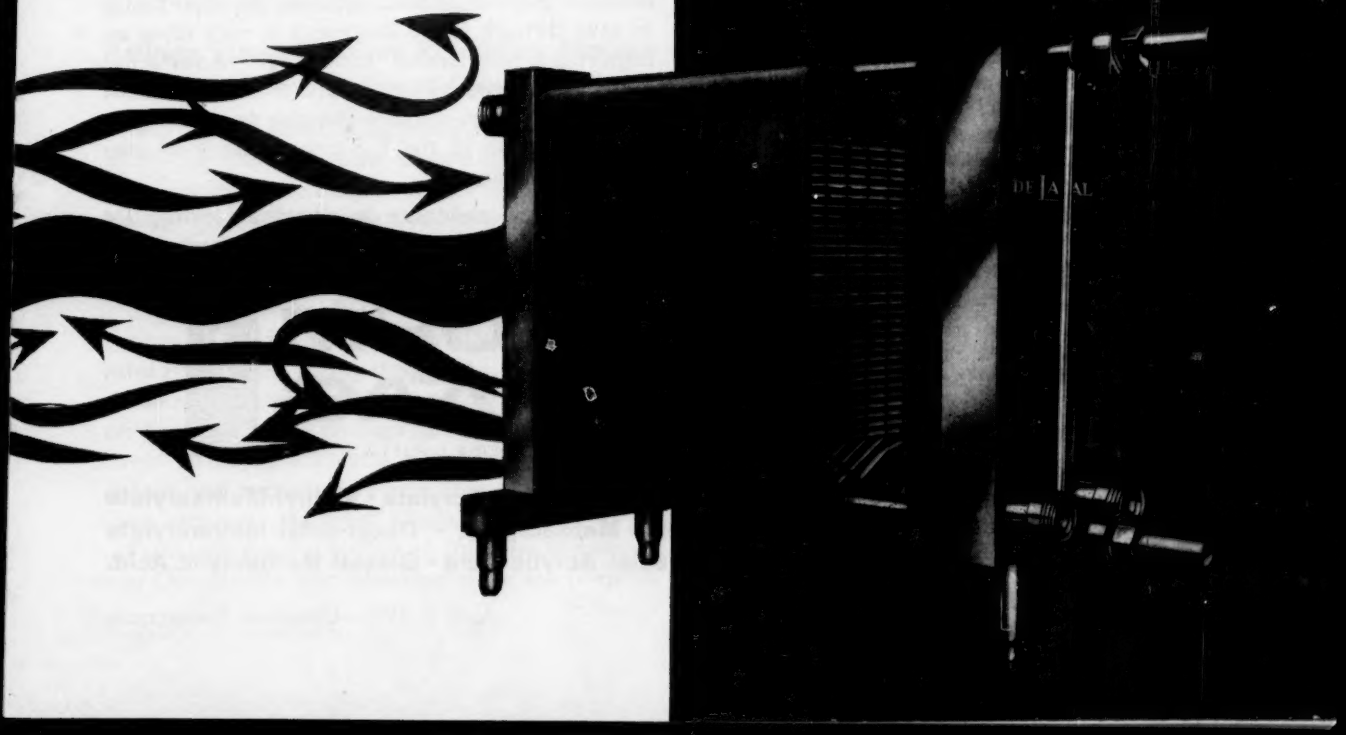
where the cost of stainless shell and tube exchangers previously made it impractical.

When partial-stainless is required: The *all* stainless De Laval PHE is almost always cheaper on an installed cost basis than stainless tubes in a steel shell—and offers many operating and maintenance benefits.

When carbon-steel is satisfactory: Even here, De Laval's all-stainless PHE's can return the higher unit cost through much cheaper installation and through annual savings because of their relative freedom from fouling and easier cleaning. Because they are free from corrosion problems and can be easily adapted or expanded to suit changing product needs, De Laval Plate Heat Exchangers are the *safe* way to handle *any* process heat exchange problem.

THE DE LAVAL SEPARATOR COMPANY

Poughkeepsie, N. Y.
5724 N. Pulaski, Chicago 46, Ill.
201 E. Millbrae Ave., Millbrae, Cal.
Dept. CE-4



CALCULATING LOWEST COST TO YOU... A ROHM & HAAS ACRYLIC MONOMER SERVICE

By analyzing carrier rates and providing detailed delivered cost data on various combination purchases, both bulk and drum, Rohm & Haas can help you plan lowest-cost purchasing of acrylic monomers.

For example, your Rohm & Haas representative could arrange shipment of two or three monomers in a compartmented tankcar or tanktruck and you would benefit by getting the bulk price on each product. Of if you buy in drums, you might purchase a mixed truckload or carload of drummed materials at carload drum prices.

Because Rohm & Haas manufactures a wide variety of both acrylate and methacrylate monomers and emulsion polymerization auxiliaries, the opportunity to save through mixed shipments is very often an important purchasing advantage. Additional advantages are: monomer plants in convenient locations for short-distance shipping to most major industrial areas in the U.S.; convenience of one-source purchasing.

Full technical assistance in planning facilities for storing and handling monomers is yours when you choose Rohm & Haas as your supplier.

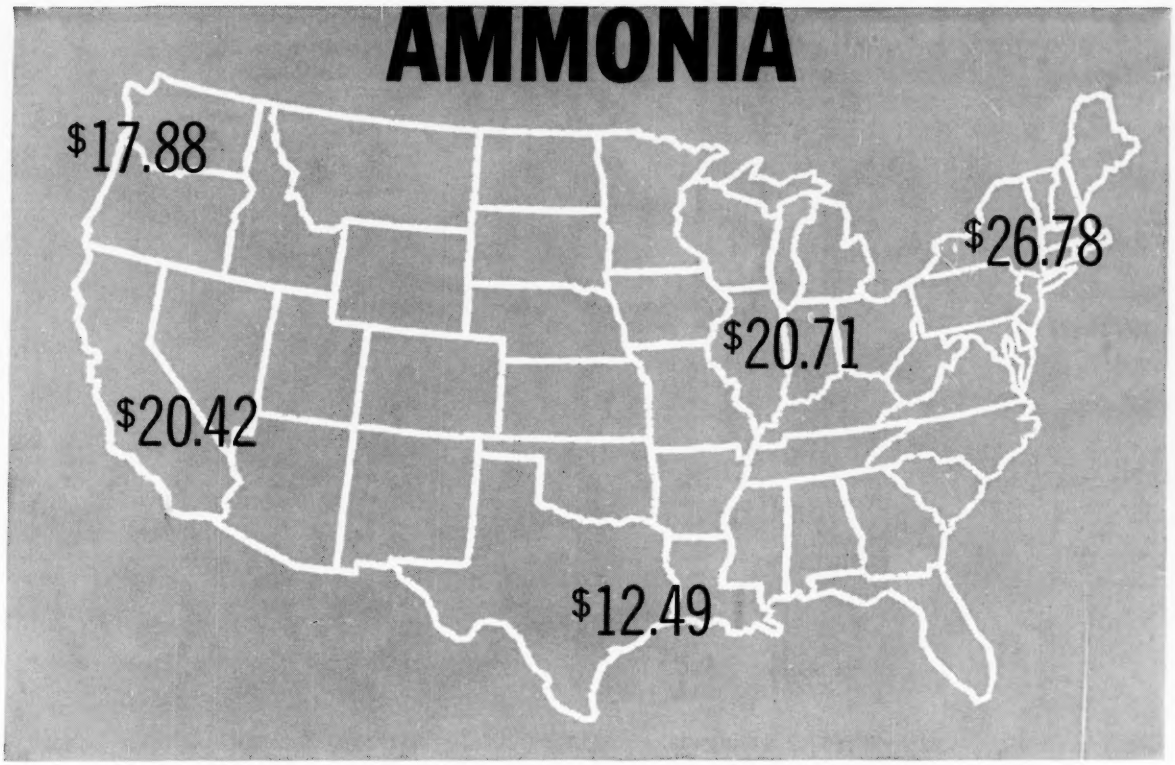
Request literature and samples from Dept. SP-4

Rohm & Haas Acrylic Monomers

ROHM & HAAS
PHILADELPHIA 5, PA.

Methyl Acrylate • Ethyl Acrylate • Butyl Acrylate • 2-Ethylhexyl Acrylate • Methyl Methacrylate Ethyl Methacrylate • Butyl Methacrylate • Hexyl Methacrylate • Decyl-octyl Methacrylate Lauryl Methacrylate • Stearyl Methacrylate • Glacial Acrylic Acid • Glacial Methacrylic Acid.

MORE PROFIT WITH AMMONIA



Kellogg Steam Methane Reforming Process Sets New Lows in Direct Operating Costs

Wherever you may be planning a new ammonia plant—for ammonia alone or as a component of a complete fertilizer complex, recent developments in Kellogg Steam Reforming now make a Kellogg-designed ammonia plant more economical than ever to operate as well as to build.

The figures shown above are direct operating costs per ton for five major U.S. areas. They are based on rates given in the utility table (right). Catalyst and chemical consumption have been included—at 34¢ per ton of ammonia product and 7¢ per ton, respectively. Labor, maintenance, taxes, insurance, depreciation and interest have not been included since these vary with individual client situations.

Feedstock for the process in this case is natural gas. Comparable low operating costs are possible with refinery gas feed, or even naphtha, under certain circumstances.

For a detailed description of Kellogg's ammonia process and other data, write for the new 12-page booklet—"Ammonia".

UTILITY UNIT COSTS*

	EAST COAST	GULF COAST	MID-WEST	PACIFIC NORTHWEST	WEST COAST
Natural Gas—Feedstock and Fuel, ¢/MM Btu	59	20	40	38	37
Electric Power, ¢/KWH	0.7	0.6	0.8	0.5	0.9
Cooling Water, ¢/M Gals.	2.4	1.8	2.5	2.2	2.2
Steam, ¢/M Lbs.	65	32	67	56	56

**Cost of steam is based on minimum fuel cost for each area*

THE M. W. KELLOGG COMPANY

711 Third Ave., New York 17. *A subsidiary of Pullman Incorporated*

Offices of other Kellogg companies are in Toronto, London, Paris, Rio de Janeiro, Caracas, Buenos Aires

This big fabrication is no tall story

It took six flat cars to ship this giant out of American Bridge's Orange, Texas, plate shop. Over 220′ long and more than 12′ in diameter, this tower is made from 33 steel rings, formed from $1\frac{3}{16}$-inch plates. High capacity boom-mounted electric welders joined the 33 rings, and special x-ray equipment checked the weld seams. ☐ What did we do for an encore? We fabricated three more towers, all about the same size—and weighing over 200 tons each. ☐ Badger Manufacturing Company, Engineers and Constructors, designed and erected the towers for a styrene manufacturing plant* now under construction for Sinclair-Koppers Chemical Company. ☐ King-size, custom fabrication is routine at American Bridge's Orange plate shop. Staffed by experienced experts, completely equipped with modern fabricating facilities,

cleared for all major tank and pressure vessel code work, and strategically located for rail, truck and water shipment; you can rely on precise, prompt and economical service on practically all plate work at American Bridge. ☐ Contact the nearest American Bridge contracting office and see how our services can work for you.

USS is a registered trademark

*Process Licensor: Cosden Petroleum Corporation

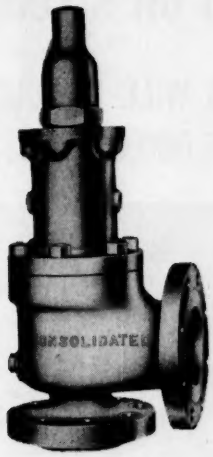
General Offices: 525 William Penn Place, Pittsburgh, Pa. • Contracting Offices in: Ambridge • Atlanta • Baltimore • Birmingham • Boston • Chicago • Cincinnati Cleveland • Dallas • Denver • Detroit • Elmira • Gary • Harrisburg, Pa. • Houston • Los Angeles • Memphis • Minneapolis • New York Orange, Texas • Philadelphia • Pittsburgh • Portland, Ore. • Roanoke • St. Louis • San Francisco • Trenton • United States Steel Export Company, New York

American Bridge Division of United States Steel

USS

top

CONSOLIDATED SAFETY RELIEF VALVES have a special "O" Ring Seat Seal that stops leakage completely



Consolidated Safety Relief Valves are available in both Standard and Balanced Bellows design for extreme corrosive applications.

tightness

The Seal is a resilient ring set in the valve disc. It maintains no-leak tightness by contact with a specially curved seating surface on the valve nozzle, yet does not carry the seat load imposed by the valve spring.

Tightness is maintained at operating pressures far closer to set pressure than with metal-to-metal seats alone. Tight closure is as efficient after "simmer" as on normal blowdown. Piping strains are absorbed far better by the resilient seal than all-metal seating. If the tough seal is ruined by entrained abrasives, replacement is easy. Seals are available in materials that resist corrosive fluids. Maintenance costs are greatly reduced.

Standard Consolidated Safety Relief Valves have an eductor tube that removes pressure from the closed bonnet. Only the spring controls valve action. You get guaranteed capacity ratings and highest dependability—absolute protection for personnel and equipment. Additionally, there is the economy of converting the Standard valve to the Balanced Bellows type in your own shop. Get complete details. Write for Bulletin 1940.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

CONSOLIDATED SAFETY RELIEF VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

Valve Division • Tulsa, Oklahoma

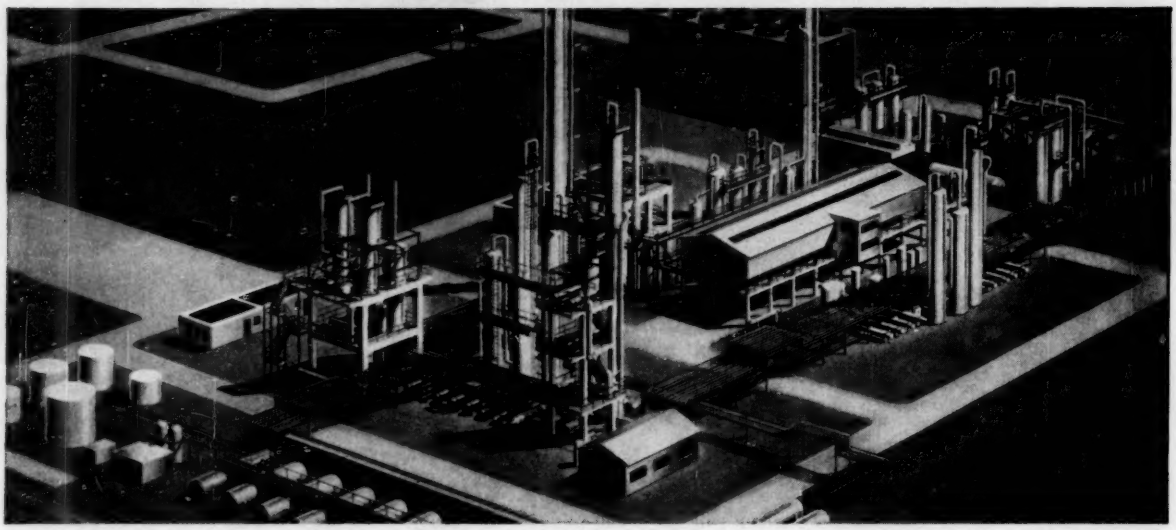
Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
Latin America: Export Division, Chrysler Building, New York, N. Y.
Europe: Manning, Maxwell & Moore, S. A., Fribourg, Switzerland

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

New $20 million Ethylene and Ethylene Oxide plant to go on stream for SunOlin in 1961

FACILITIES WILL PRODUCE 225,000,000 LBS. OF ETHYLENE AND 55,000,000 LBS. OF ETHYLENE OXIDE PER YEAR



The Lummus Company has been awarded the contract to design, engineer and construct a $20 million ethylene and ethylene oxide plant for SunOlin Chemical Company at Claymont, Delaware.

The plant is scheduled to go on stream late in 1961, and will have a design capacity of 225,000,000 lbs. of ethylene and 55,000,000 lbs. of ethylene oxide per year. Existing facilities will be modified to permit production of 12,000,000 cubic feet of high-purity hydrogen and up to 1,000,000 cubic feet of carbon monoxide per day.

The new units will be located at Claymont, Delaware, adjacent to the Sun Oil Company's Marcus Hook Refinery which will supply the raw material for the plant.

A substantial portion of the products produced will be used to supply the requirements of major chemical companies in the area. To permit efficient delivery of ethylene and other petrochemicals, a multiple pipe line crossing will be laid under the Delaware River from the site to serve customers in the expanding Southern New Jersey industrial area.

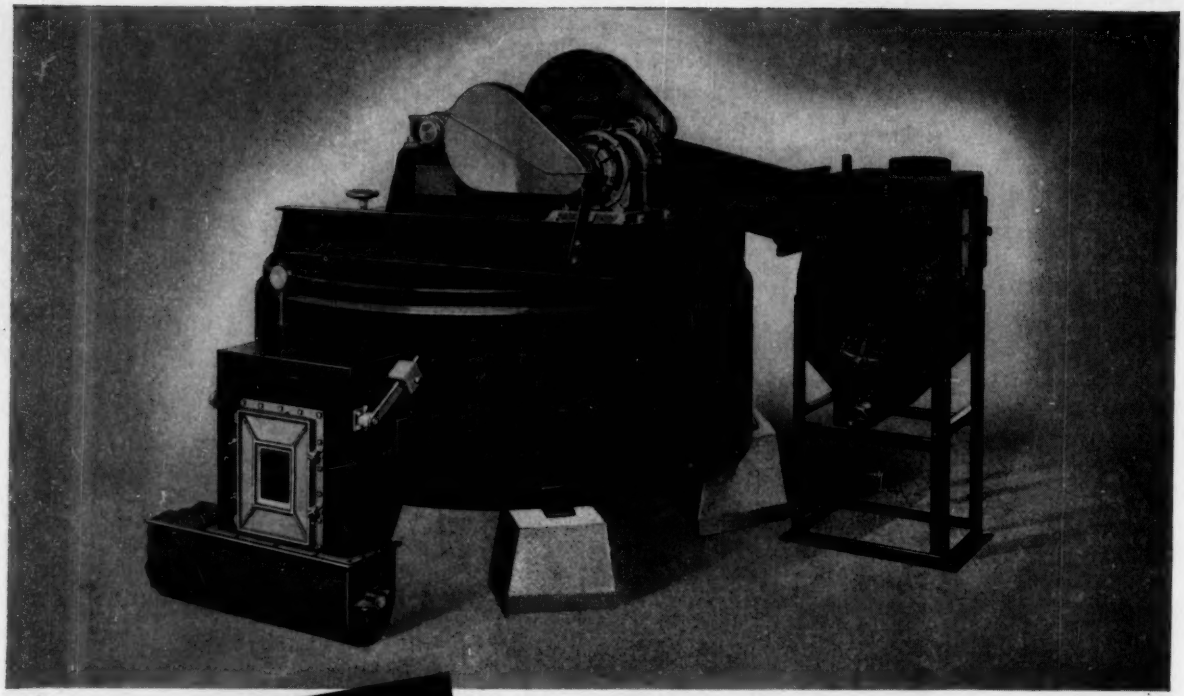
The remainder of the production will be used in the manufacture of products marketed through existing sales outlets of Sun Oil Company and Olin Mathieson Chemical Corporation, the joint owners of SunOlin.

The plant will employ Lummus' low-temperature ethylene separation process, which provides high separation efficiencies and unusual flexibility and reliability; and Shell Development Company's ethylene oxide process, which offers the advantages of unusually high yields and virtual elimination of waste disposal problems encountered in the classic Chlorohydrin Process.

SunOlin is the fourteenth ethylene, and the fifth Shell Process ethylene oxide plant to be designed, engineered, and constructed throughout the world by Lummus.

Lummus has over 50 years' experience in the design and construction of more than 850 plants for the world-wide process industries. Call Lummus on your next project.

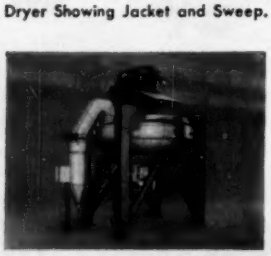
THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, New York, Houston, Washington, D. C., Montreal, London, Paris, The Hague, Madrid; Engineering Development Center: Newark, N. J.



BARTLETT-SNOW
CLEVELAND 5, OHIO

BATCH DRYERS

Cutaway View of Standard Batch Dryer Showing Jacket and Sweep.



Special Stainless Steel Batch Dryer for Processing a Finely Divided Catalyst Without Dust Loss.

Dryers 6 ft., 8 ft. and 10 ft. in diameter with capacities of 1200, 3000 and 6000 lbs. per charge respectively are standard. Steam jacketed or direct fired. Atmosphere or vacuum processing. Also "Specials" to meet any unusual service requirement.

These Style A (atmosphere) and Style AV (vacuum) dryers are ideally suited for treating chemical salts, pigments, precipitates, activated carbon, filter cake, tankage and a wide variety of organic products. The charge is loaded through the top. An "S" shaped sweep agitates the material to assure uniform, thorough treatment, and discharges the dried material through the side outlet door.

Standard designs can be equipped for dust-tight discharge to a screw conveyor, and fitted with a vapor exhaust condenser to reclaim the fines, see view above. Variations from standard include those with dished bottoms, remote controlled discharge doors, and other ingenious arrangements to meet unusual service requirements. Let us work with you on your next project!

DESIGNERS
ENGINEERS
FABRICATORS
ERECTORS

THE C. O. BARTLETT & SNOW CO.
6215 Harvard Ave., Cleveland 5, Ohio
DRYERS • COOLERS • CALCINERS • KILNS

Bulletin No. 118 gives full details. Send for a copy Today.

ANOTHER ACHIEVEMENT IN MODERN FLOW CONTROL BY CRANE

CRANE 125-AND 150-POUND UNION BONNET BRONZE GATE VALVES

STRONGER CYLINDRICAL BODY DESIGN FOR LONG SERVICE LIFE

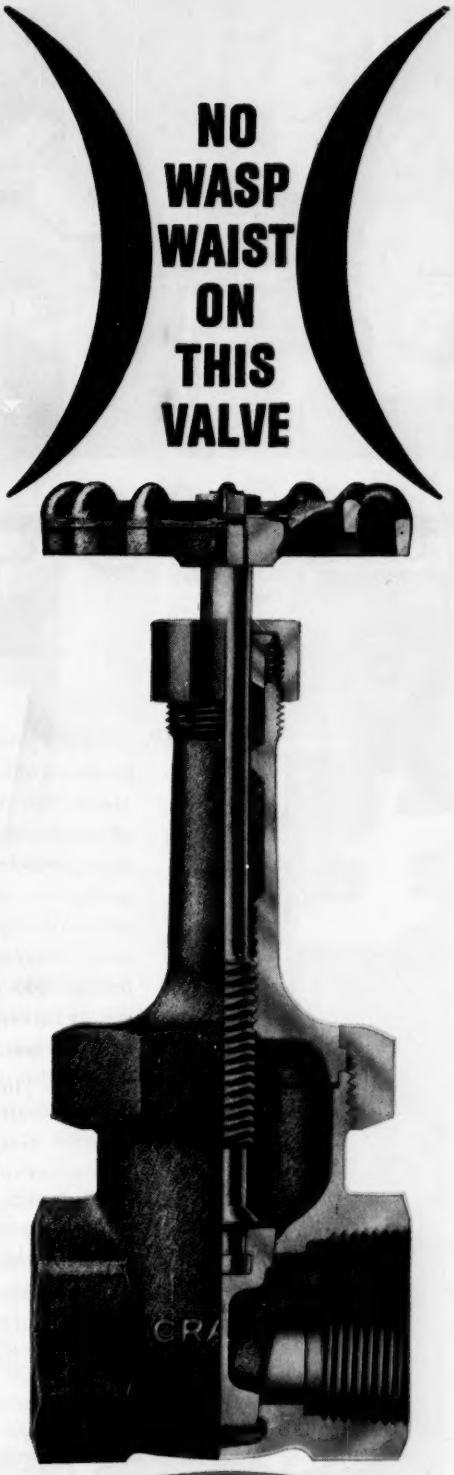
Every part of these new valves has been carefully engineered and liberally proportioned to assure an extra safety factor over the recommended working pressures. Unlike ordinary pinched-in, rectangular body valves, Crane's cylindrical body—the same design used in Crane's heavy-duty 200- and 300-pound bronze gate valves—distributes pressure loads uniformly and reinforces seat against the wedging action of the disc.

Wider, huskier hex ends combined with the new body shape give this valve greater rigidity, reduce chance of leakage and early failure resulting from piping strains. They make for easy installation, too.

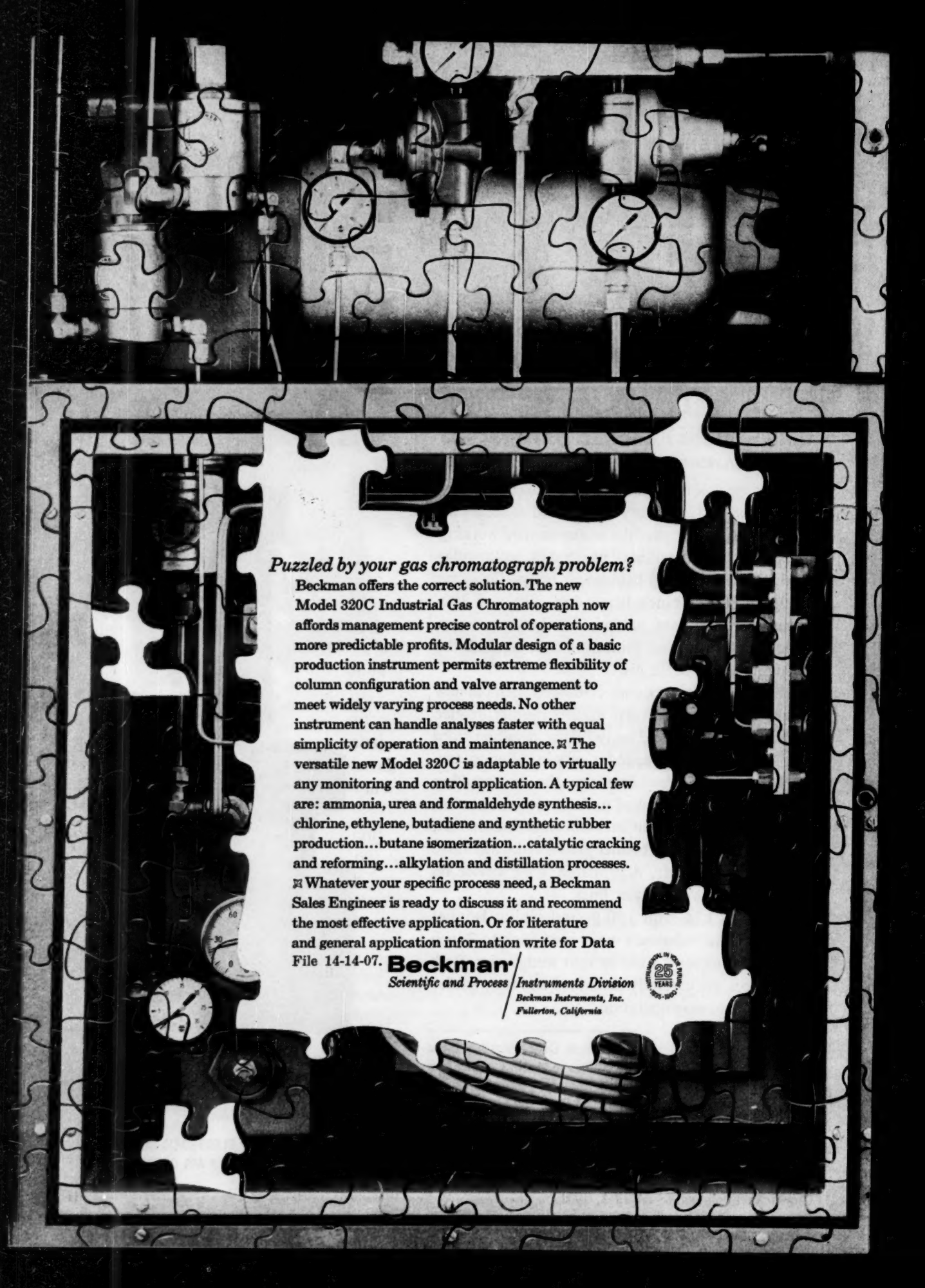
Many other Crane features—the deep stuffing box that can be repacked under pressure, substantial thread engagement between stem and bonnet, and a precisely fitted bonnet joint—make this valve a best buy for safe, dependable, long service on steam, oil, gas and water lines.

Crane's 125- and 150-pound Union Bonnet Bronze Gate Valves are made in ¼-inch to 2-inch sizes with either a solid or split wedge disc. Both disc types are carefully machined and fully guided for positive, easy operation.

Your Crane Distributor has these new valves in stock. Contact him for information or write Crane Co., Industrial Products Group, 4100 S. Kedzie Avenue, Chicago 32, Ill. In Canada, Crane, Ltd., 1170 Beaver Hall Square, Montreal.



VALVES • PIPING • ELECTRONIC CONTROLS
PLUMBING • HEATING • AIR CONDITIONING



Puzzled by your gas chromatograph problem?

Beckman offers the correct solution. The new Model 320C Industrial Gas Chromatograph now affords management precise control of operations, and more predictable profits. Modular design of a basic production instrument permits extreme flexibility of column configuration and valve arrangement to meet widely varying process needs. No other instrument can handle analyses faster with equal simplicity of operation and maintenance. ¤ The versatile new Model 320C is adaptable to virtually any monitoring and control application. A typical few are: ammonia, urea and formaldehyde synthesis... chlorine, ethylene, butadiene and synthetic rubber production...butane isomerization...catalytic cracking and reforming...alkylation and distillation processes. ¤ Whatever your specific process need, a Beckman Sales Engineer is ready to discuss it and recommend the most effective application. Or for literature and general application information write for Data File 14-14-07.

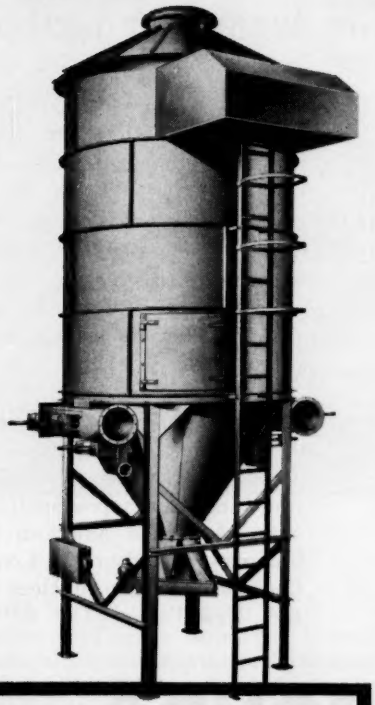
Beckman

Scientific and Process Instruments Division

Beckman Instruments, Inc.
Fullerton, California

25 YEARS

COLLECTS DUST at 550°F



MULTIPLE ARRANGEMENTS

Several AAF glass cloth collectors placed in parallel arrangement offer an infinite range of air volumes, and also permit continuous application of "intermittent-type" units.

This new glass cloth collector is designed for high-efficiency operation at temperatures far above the 250°F limits of standard fabric arresters. It's AAF's new AMER-therm high-temperature arrester for the collection of extremely fine dust or dust which must be reclaimed dry.

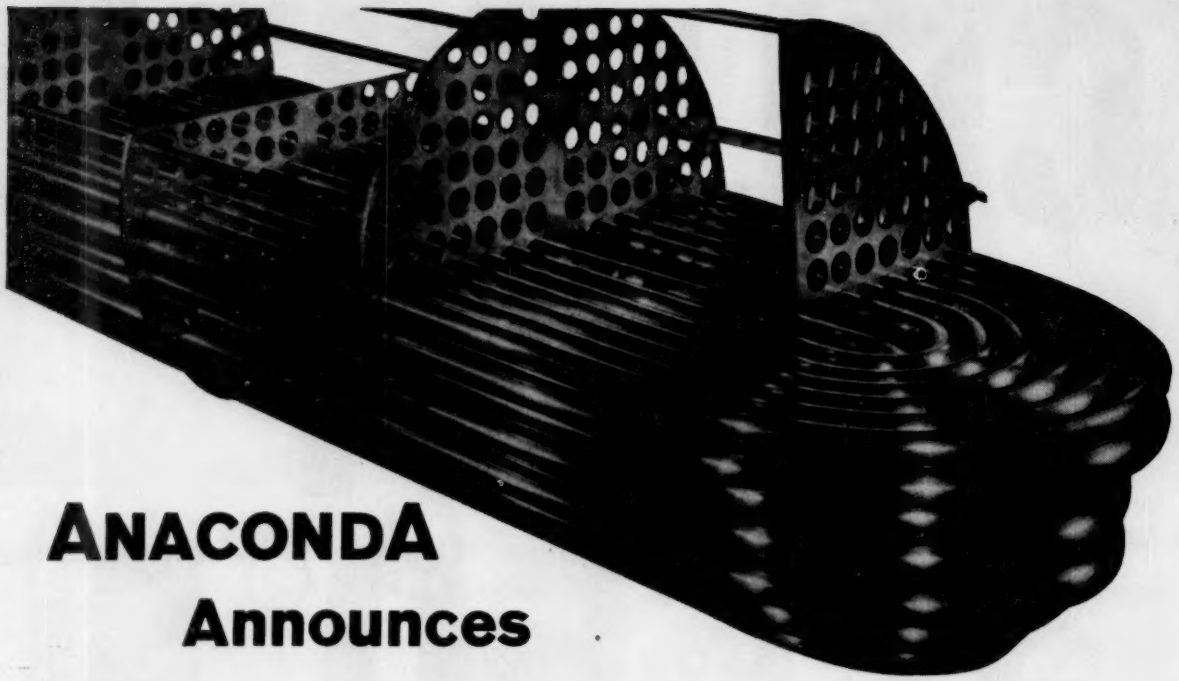
Glass cloth bags now make it possible to handle *dust loadings of varying nature at temperatures up to 550°F.*

Maintenance, including bag replacement, is quick and simple, too. Housing and hopper panels are zinc grip coated steel and never need painting.

AAF's AMER-therm glass cloth collectors range in size from 1,900 cfm up for both intermittent and continuous operation. For complete information write for Bulletin 283. Address: Mr. Robert Moore, American Air Filter Company, Inc., 326 Central Avenue, Louisville 8, Ky.

AAF American Air Filter

BETTER AIR IS OUR BUSINESS



ANACONDA Announces

A new high-strength copper-nickel-iron tube alloy that makes possible substantial economies in feedwater heaters

Research metallurgists of Anaconda American Brass Company have developed, after three years of intensive effort, a new high-strength copper-nickel-iron alloy — Cupro Nickel, 30%-707—for heat exchanger tubes in power plant feedwater heaters.

Alloy 707 has mechanical properties comparable with those of a premium high-strength alloy now commonly used, and retains its strength at elevated temperatures—allowing working stresses up to 15,200 psi at 600° F. Thus, in an important area of high-temperature heater application it provides material-cost advantages.

And as these high mechanical properties are for the metal in the *annealed* condition, Alloy 707 tubes can be readily cold worked—can be expanded into tube sheets and formed into tight U-bends.

MECHANICAL PROPERTIES of Cupro Nickel, 30%-707 (nominal composition, copper 64.15%, nickel 30.00%, iron 5.25%, manganese 0.60%) are as follows:

Tensile Strength, min, psi	74,000
Yield Strength, (0.5% Extension under Load), min, psi	36,000
Elongation, % in 2", min	30
Expansion of Tube Inside Diameter with Tapered Pin, %, min	30

STRENGTH AT ELEVATED TEMPERATURES. Extensive tests at room and elevated temperatures show that design stresses given below can be used for Alloy 707:

Maximum Metal Temperature, °F	Maximum Allowable Stress Values in Tension, psi
100	18,300
150	17,800
200	17,500
250	17,100
300	16,800
350	16,400
400	16,100
450	15,900
500	15,600
550	15,400
600	15,200

WELDABILITY. Alloy 707 can be welded by the same methods used for regular 30% cupro nickel.

CORROSION RESISTANCE. Alloy 707 has the same high resistance to stress-corrosion cracking and the same excellent resistance to corrosion by salt water as regular 30% cupro nickel.

FOR MORE DETAILED INFORMATION on this new high-strength tube alloy, Cupro Nickel, 30%-707, see your Anaconda representative, or write: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6160

ANACONDA®

TUBES AND PLATES FOR CONDENSERS AND HEAT EXCHANGERS

Anaconda American Brass Company

COPPUS BLUE RIBBON PRODUCTS

Coppus Steam Turbine with Built-In Speed Reducer

STAMINA — You can literally *see* stamina in every dimension of a Coppus Turbine . . . rugged reliability that assures you stable, positive performance. It truly "wins" the Blue Ribbon with which it is marked . . . through advanced design, top quality materials, and thorough testing. With Coppus you're always certain of Blue Ribbon features such as these —

A totally enclosed governor . . . totally enclosed, independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. Sizes from 1 HP to 250 HP. All Coppus Products carry the same Blue Ribbon assurance of reliable performance. For further facts on turbines, send for new Catalog 200. COPPUS ENGINEERING CORPORATION, 224 Park Ave., Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES

CAN YOU AFFORD THE HIGH COST OF CORROSION?

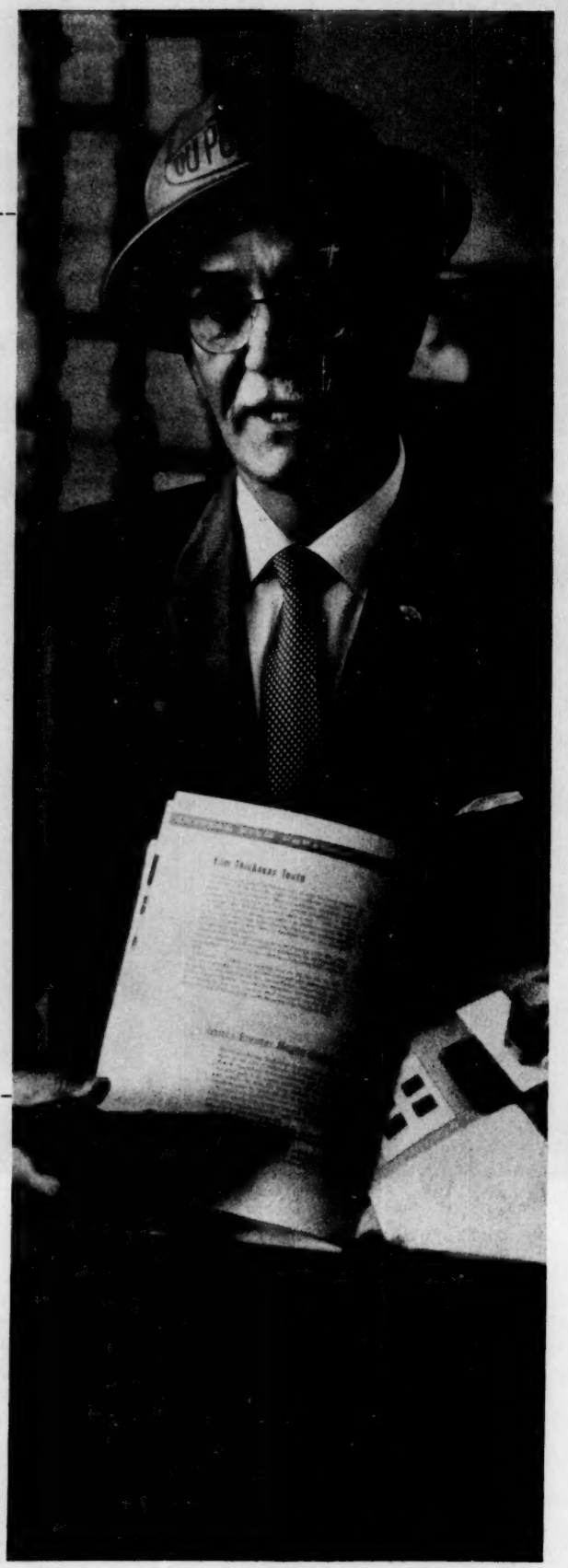
The answer is no—if you want to maintain a healthy profit picture, says Dick Durham. Dick's a member of Du Pont's special Technical Service Group—an old-timer in the field of maintenance painting. His job: to help you hold down mounting maintenance costs. As Dick sees it:

"No one can afford the high cost of finishes that fall down on the job. Which means thinking in terms of CPSFPY—cost per square foot per year—rather than cost per gallon. CPSFPY—Du Pont's approach to paint maintenance—brings in two additional factors of equal importance: technical service and long-term economy.

"You see, when you specify Du Pont, you're getting a complete paint system, geared to your specific needs. It starts, of course, with top-quality paints—like our DULUX® Metal Protective Finishes. These fine finishes can take care of 85% of your maintenance painting requirements, with considerable economy. For surfaces subject to severe corrosive conditions where these finishes are not recommended, Du Pont has developed CORLAR(T.M.) Epoxy Chemical-Resistant Enamels and IMLAR(T.M.) Vinylmastic Coatings and Vinyl Enamels.

"Teamed with top-quality paints is technical service. This means going right into your plant to analyze your problems at firsthand. Then we can sit down with your engineers or plant supervisors and draw up a sound, workable program that considers both maintenance and budgetary requirements. Result: efficient, long-range protection, at lowest cost per square foot per year."

There are men like Dick Durham working out of Du Pont district sales offices from coast to coast. Why not let one of them put his training and experience to work for you? For detailed information on DULUX Metal Protective Finishes, CORLAR and IMLAR enamels, clip and mail the coupon below. You'll be under no obligation whatever.



E. I. du Pont de Nemours & Co. (Inc.)
Finishes Division, Department CE-4, Wilmington 98, Delaware

Please send me, without obligation:

- ☐ Du Pont technical bulletin on DULUX Metal Protective Finishes.
- ☐ Du Pont technical bulletin on CORLAR Epoxy Enamels.
- ☐ Du Pont technical bulletin on IMLAR Vinylmastic Coatings and Vinyl Enamels.

Name_____

Firm_____

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City_____ Zone____ State_____

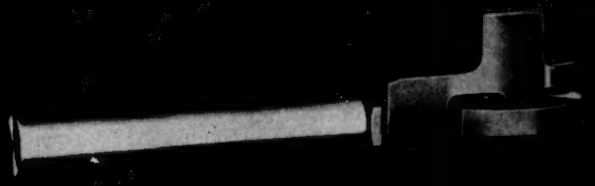
MAINTENANCE PAINTS

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

NEW Butterfly Valve!



MATCHLESS LUNKENHEIMER QUALITY

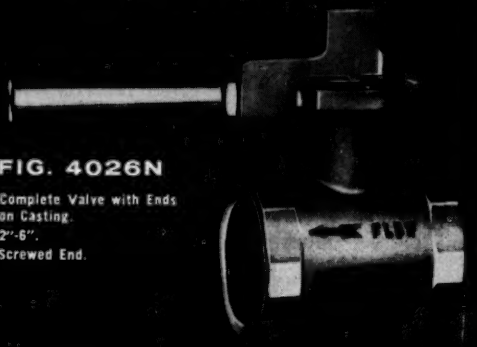


FIG. 4026N

Complete Valve with Ends on Casting.
2"-6".
Screwed End.

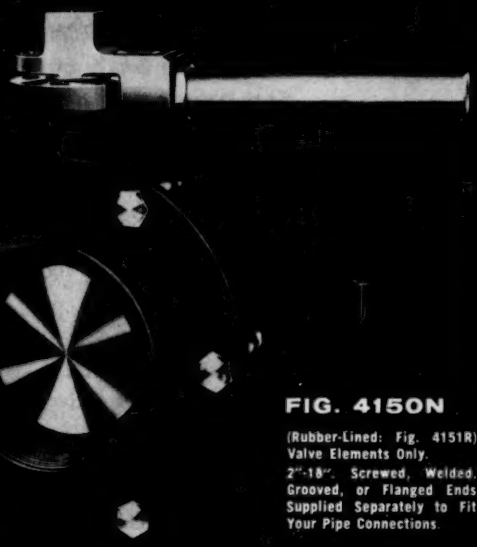


FIG. 4150N

(Rubber-Lined: Fig. 4151R) Valve Elements Only.
2"-18". Screwed, Welded, Grooved, or Flanged Ends Supplied Separately to Fit Your Pipe Connections.

W. P. 150 psi.

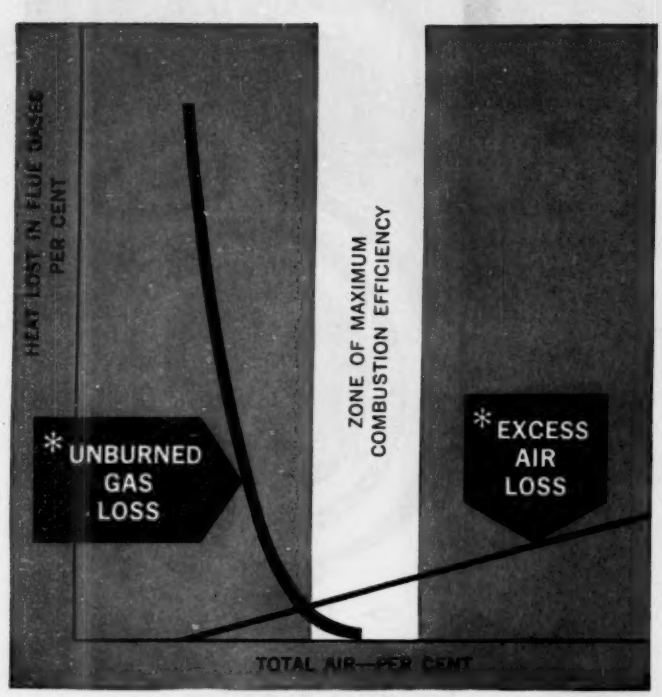
- QUICK OPENING
- POSITIVE CLOSURE
- NICKEL-PLATED CAST IRON
- STAINLESS STEEL TRIM
- "O" RING SEALS

New Lunkenheimer Butterfly Valves are compact and lightweight, easy to install on any line in a fraction of the space required by standard gate or plug valves. A quarter-turn of the stem opens the disc full or closes it tight. No lubrication is required, and "O" Ring seals provide positive shut-off in either vacuum or pressure service. These new Butterfly Valves are made to traditional Lunkenheimer standards of quality. WRITE for new Catalog 613 or call your Lunkenheimer distributor today for full information on the new Lunkenheimer Butterfly Valve line . . . available now for immediate delivery.

L-361-23

LUNKENHEIMER®

You must know BOTH* to get maximum combustion efficiency!

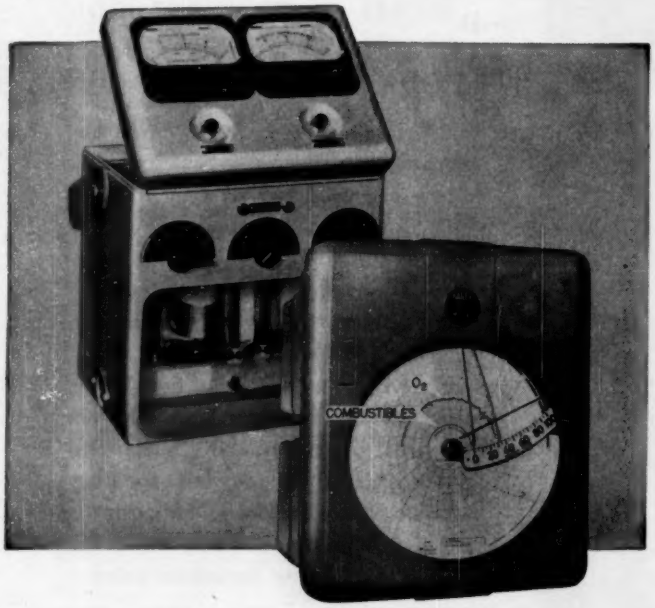


How much money is going up the flue in *unburned fuel* losses? Is too much air resulting in excessive *heat* losses?

You must know *both* facts—simultaneously—to get optimum combustion. No instrument that measures only one of these interdependent factors can give you the full information you need.

Bailey offers a choice of two direct ways to maintain a continuous and simultaneous double check on these factors that determine combustion efficiency. The portable, lightweight Bailey HEAT PROVER Analyzer indicates both; the Bailey Oxygen-Combustibles Analyzer-Recorder records both on a single chart. Both instruments measure excess air, regardless of fuel or fuels being burned, and per cent of combustibles in flue gas.

Either of these Bailey instruments can save you far more than their cost in spotlighting combustion inefficiencies. Ask your Bailey engineer or write for product specifications.



2 DIRECT WAYS
to measure both combustibles and oxygen simultaneously

PORTABLE INDICATOR—Self-contained, lightweight, Bailey HEAT PROVER Analyzer enables quick, easy check on combustion conditions. Dual range dials for greater accuracy and readability.

PERMANENT RECORDER—Bailey Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart . . . is designed for permanent installation . . . helps maintain optimum ratio continuously.

* Unburned gas loss and excess air loss.

CP 112-1

Chemical and Petroleum Division

BAILEY METER COMPANY

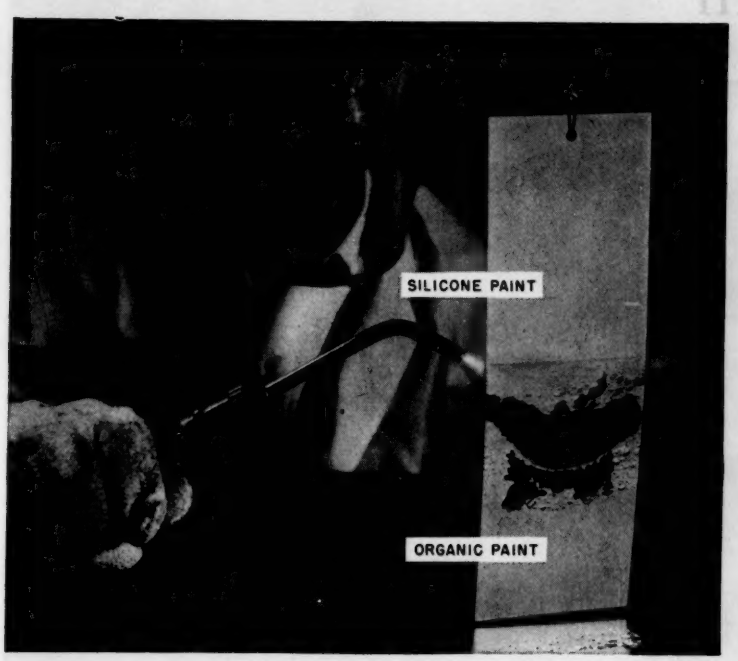
1054 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

SILICONE NEWS from Dow Corning

New Paint For Hot Spots



Silicone-based paints stay put ...resist corrosion, weathering

Guarding metal surfaces from weathering and chemical attack is tough enough. Keeping them protected when surface temperatures climb to 700 F, 800 F — even 1000 F — is tougher still. Most paints fail rapidly, blister and peel. But paints based on Dow Corning Silicones retain their protective properties, even on the hottest jobs.

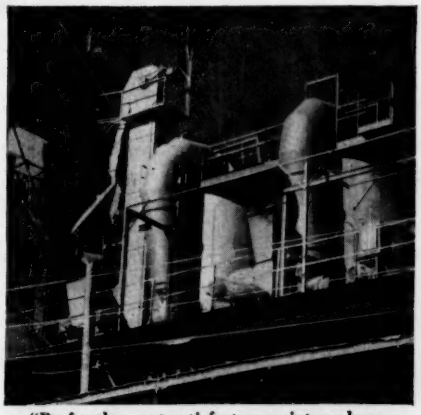
Whether the surface stays hot, or shuttles between hot and cold, makes no difference to a silicone paint. Here's a new kind of protective coating . . . one that you can depend on to provide real protection, withstand oxidation, corrosive atmospheres or weathering. When paint lasts like this — from 25% to 100% longer — you save money because (1) less paint is required; (2) costly downtime and labor are greatly reduced.

Another plus: Silicone-based paints are available in a wide range of colors. This means you can carry color-coding over onto hot equipment without worrying about early paint failure. To new product designers, this feature means finishes that resist chalking, checking, fading — retain their original beauty and protection.

For protecting a "hot spot" or a "hot product", it'll pay you to use paints made with Dow Corning silicone resins. Write today for more information.

"After 5 years, silicone paint still protects bronze-melting furnace. Organic paints failed within days after application."
BEARING MANUFACTURER

"After two years, mufflers coated with silicone paint are still in good shape. Organic paint used on similar 500 F mufflers burned away long ago."
PUBLIC UTILITY



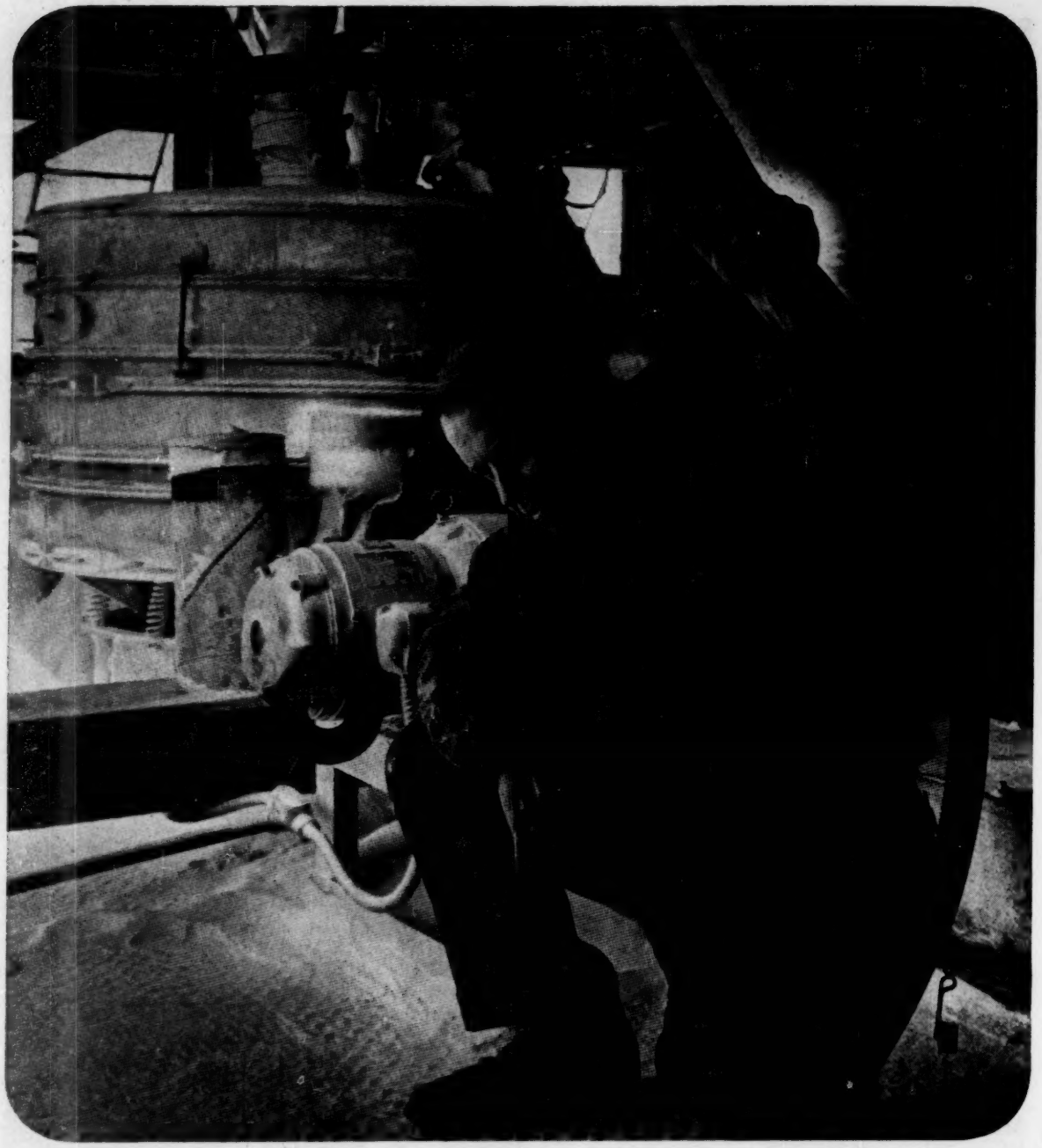
"By far the most satisfactory paint we have ever used on kilns and stacks with surface temperatures of 650 to 750 F."
BASIC CHEMICAL MANUFACTURER

Send for illustrated brochure, "Why Silicone-Based Paints Mean Less Maintenance", plus list of suppliers. **Address Dept. 1816**

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.



Only 'round the clock screening meets Maas' custom requirements

SWECO Vibro-Energy Separators operate 24 hours a day, seven days a week, at A. R. Maas Chemical Co., division of Stauffer Chemical Co., South Gate, Calif. Costly down-time and maintenance ordinarily caused by screen blinding are reduced to a minimum with SWECO's effective ball tray design. Maas installed one of the first SWECO Separators in 1953. Today, seven 48-inch, multiple-deck units handle its production of photo chemicals, organic chelating agents, and a complete line of sodium phosphates, all to exacting customer specifications. Units transmit no vibration so are easier and more economical to install, and they use only 1/3 of the normal power required. The SWECO Separator's quick screen change and longer screen life cut operating and maintenance costs. For full details, application data, or free screening demonstration in *your* plant with *your* materials, write SOUTHWESTERN ENGINEERING CO., 4800 Santa Fe Avenue Los Angeles 58, Calif., Dept. 3632.

SWECO

✦Vibro-Energy separators, grinding mills, finishing mills✦

LOOK WHAT THIS ONE PUROLATOR UNIT WILL FILTER!

AND PRACTICALLY ANY OTHER FLUID OR SLURRY YOU CAN NAME! The G-140 series will remove all impurities from 25 microns on up. Even highly corrosive fluids can be filtered with stainless steel models. Installation can be made on either the pressure or suction side of the pump.

Continuous, permanent filtration. Best of all, the G-140 series' filtering unit need never be replaced. Made of precisely-spaced metal ribbon wound into cylinder form, the filtering element will last the life of the filter.

Cleans with a twist of a handle. A twist of the handle on top of the unit cleans the filter. No need to disassemble the unit or stop the flow of fluid. Turning the handle rotates filter unit against fixed knife blade which shears off waste—which is periodically removed through drain at the bottom. If service warrants, filter element can be rotated continuously by motor drive.

Other specifications. Degree of filtration: 25 to 500 microns. Element spacing: .001" to .020". Capacity. 6-200 GPM. Weight: 100 lbs. Operating temperature: up to 650°F. Operating pressure: 150 psi. Relief valve available on special order. ASME coded vessels also available.

For full specifications and application information write: Purolator Products, Inc., Rahway, New Jersey.

Filtration for Every Known Fluid

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Rahway, New Jersey, and Toronto, Canada

First privately owned and operated space-age plant
furnishes liquid hydrogen
to missile centers
and industrial users

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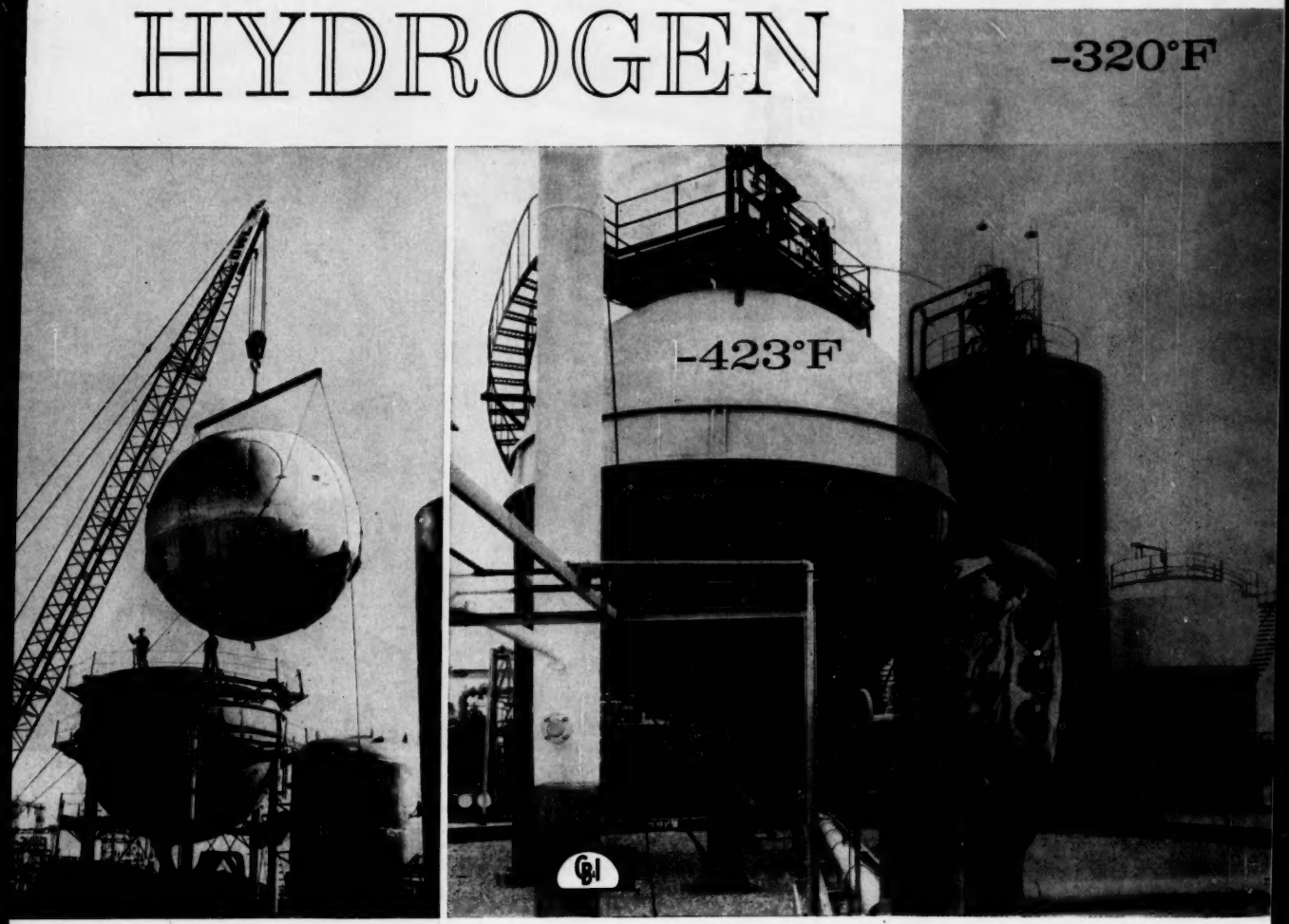
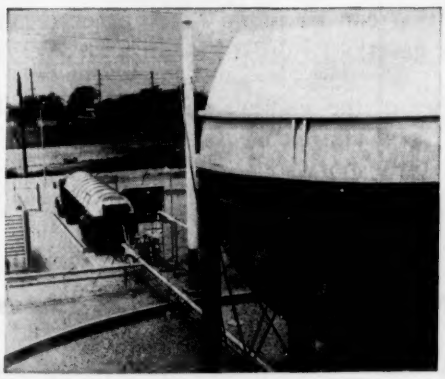
HYDROGEN



These double-wall cryogenic storage tanks play a vital role in the first privately-owned plant to supply liquid hydrogen on a large-scale commercial basis. Hydrogen is stored in the sphere at −423°F and nitrogen in the cylindrical tank at −320°F. Located in Torrance, Calif. and owned by Linde Company, Division of Union Carbide Corporation, the plant will deliver 3,300,000 lbs. of liquid hydrogen yearly to missile centers. Both tanks were designed (using Linde-approved designs), fabricated and erected by CB&I, world's most experienced builder of cryogenic vessels.



ABOVE: Aluminum inner shells and carbon steel outer shells were used for the two cryogenic tanks. The spherical tank is 28 ft. in diameter and the cylindrical tank 21½ ft. Special insulation is between the shells.

TOP LEFT: The inner sphere is suspended in the outer sphere by stainless steel rods positioned around the perimeter. Resting on the ground nearby is the aluminum inner shell of the cylindrical nitrogen tank.

LEFT: A trailer is being loaded with liquid hydrogen for delivery to missile centers, other government installations, or industry.

CB&I

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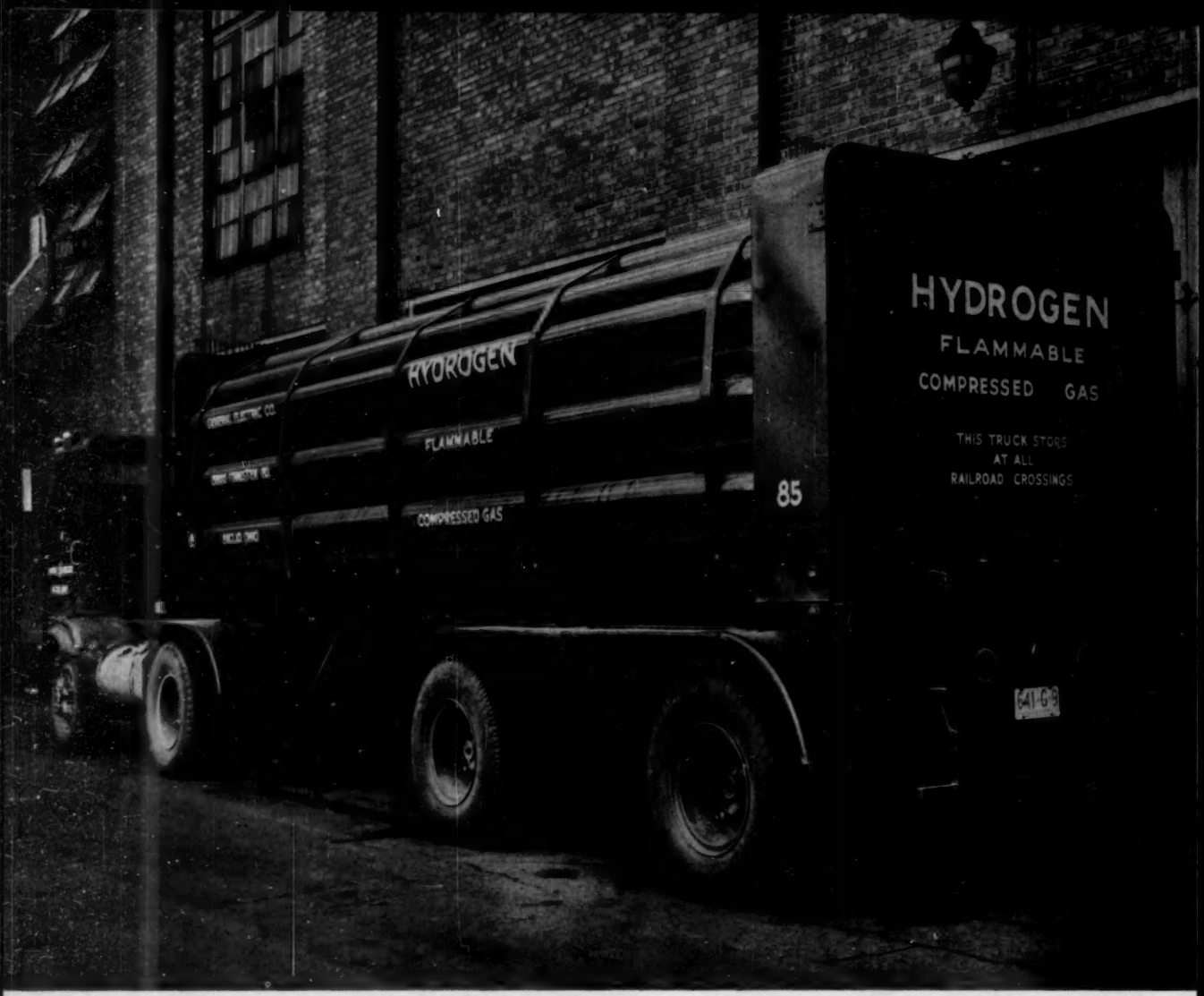

General Electric Company is one of the many big names in American industry which has adopted Taylor-Wharton Gas Transports as their means of transporting industrial gases.

Low initial *cost* and extreme *mobility!* — an efficiency and economy that can be found in no other means of distributing industrial gases!

Many other of the nation's gas producing, oil refining, petrochemical, food and electronic companies now employ flexible, mobile gas transports.

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Why a Steam Trap Has to Handle "Air"

Low temperatures and corrosion of equipment are often evidence of inadequate trap air venting capacity

Air, with its load of oxygen and carbon dioxide, has an unwholesome habit of interfering with the efficiency of steam heated units. If steam were always free of these undesirable companions, things would be a lot simpler for men-who-operate-plants. Because it isn't, three unhappy situations frequently occur:

1. ***Operating temperatures are subnormal.*** This is a two-part problem. First, an air-steam mixture has a lower temperature than pure steam at the same pressure—see Table A. Secondly, air can "plate out" on heat transfer surfaces as shown in Figure 1. Under some conditions, such an air film will knock down heat transfer efficiency by as much as 50%.

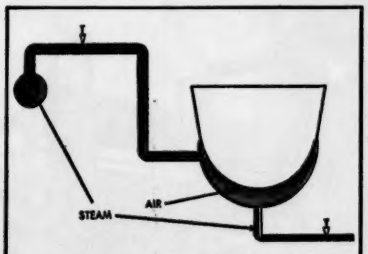


Fig. 1. *How air can "plate out" on heat transfer surfaces. This "insulation" drastically reduces heat transfer efficiency. Armstrong trap operation creates turbulence in the equipment that prevents this.*

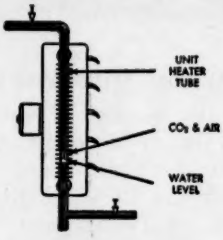


Fig. 2. *Corrosion occurs when units are not kept continuously free of both condensate and air. Armstrong traps discharge both,* at steam temperature, *as fast as they accumulate.*

2. ***Corrosion rears its ugly head.*** Oxygen and carbon dioxide are real trouble-makers. CO_2 gas goes into solution in condensate, forms carbonic acid and chews away at vulnerable metal sections. O_2 aggravates situation. See Figure 2.

TABLE A—How air reduces steam temperature.

Gauge Pressure	Temp. of Steam with No Air Present	Temp. of Steam Mixed With Various Amounts of Air (% Air by Volume)	
		10%	30%
10.3	240.1	234.3	220.9
25.3	267.3	261.0	246.4
50.3	298.0	291.0	275.1
75.3	320.3	312.9	295.9
100.3	338.1	330.3	312.4

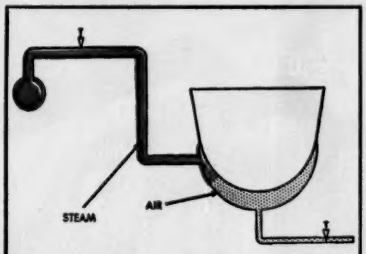


Fig. 3. *When steam is turned on, it takes a trap with extra air venting capacity to provide fast heat-up.*

3. ***Heat-up is slow as a snail.*** Air has a picnic in units that are shut off periodically. Figure 3 pictures the problem. Lines and equipment literally fill up with air. When the steam is turned on it can get in only as fast as the air gets out.

Enter Steam Traps

Curing these steam system ailments involves an operation sometimes called a "trap transplant." It consists of removing traps that don't get the air out and replacing them with traps that do.

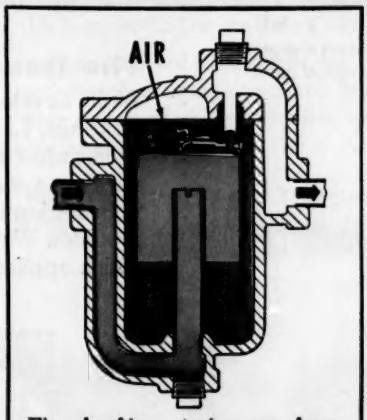
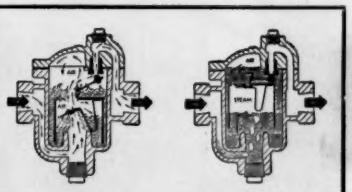


Fig. 4. *Air entering an Armstrong trap passes through the bucket vent and accumulates in the top of trap. When trap opens, air is discharged along with condensate.*

Figure 4 shows how an Armstrong inverted bucket trap continuously vents air. What the picture doesn't show is a built-in plus-value of this trap's design. An Armstrong trap opens suddenly, creating a momentary pressure drop and turbulence in the unit being drained. This breaks up air films and "pumps" air down to the trap so it can be vented.

The vents in standard Armstrong trap buckets will pass all the air normally encountered. In special cases, such as paper machine dryers, the vents are correctly sized larger at the factory to meet the requirement.



Thermostatic vent open. *Thermostatic vent closed.*

Fig. 5. *Open float with thermostatic vent for off-and-on units. When trap is cold, vent is open, permitting air to blow through when steam is turned on. When steam reaches trap, heat closes thermostatic vent. Then, regular bucket vent handles all air coming in with steam.*

Open Float with Thermostatic Vent

Super air-venting capacity is a must for fast heat-up of low pressure unit heaters, heating coils, steam headers and other units that are on-and-off. Figure 5 shows how the Armstrong open-float-with-thermostatic-vent trap takes care of this.

* * *

The 44-page Armstrong steam trap book covers other features of the Armstrong trap as well as its excellent air handling characteristics. This catalog also discusses trap selection, installation and maintenance. Your local Armstrong Representative or Distributor will be glad to give you a copy. Call him, or write Armstrong Machine Works, 8583 Maple Street, Three Rivers, Michigan.

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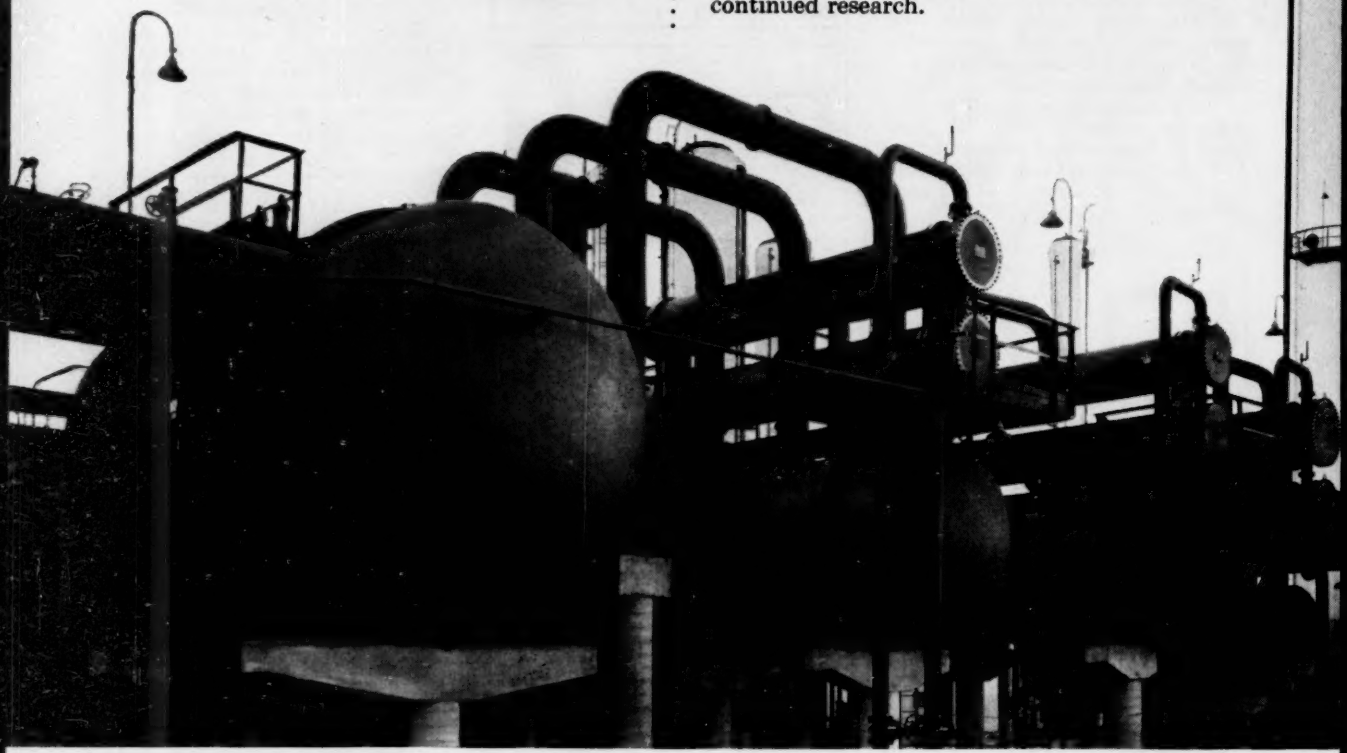

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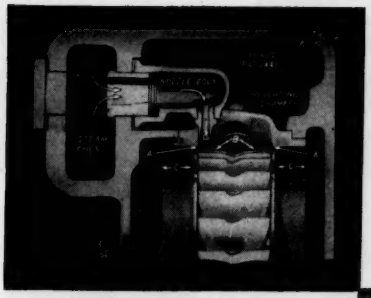

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1 ***Generous wheel clearances:*** AA —rim clearance, B—blade clearance, CC —side clearance. Blades can't foul as they are protected by rims. Rubbing at AA will do no damage. Side clearance is so large (about one inch) that end-play from excessive external thrust cannot damage wheel.

2 ***Blade wear is of little consequence.*** In a Terry solid-wheel turbine, the steam enters the buckets at right angles to the shaft. As its power-producing action takes place on the curved surfaces at the backs of the buckets, wear does not materially affect horsepower or efficiency.

To prevent costly shutdowns for repairs, Terry builds bonus reliability into each solid-wheel turbine. Two of the ways in which this is accomplished are shown in the diagrams at the left.

Further details of these simple, fool-proof turbines are illustrated and described in bulletin S-116. If you do not already have a copy of this publication, send for one today. No cost or obligation.

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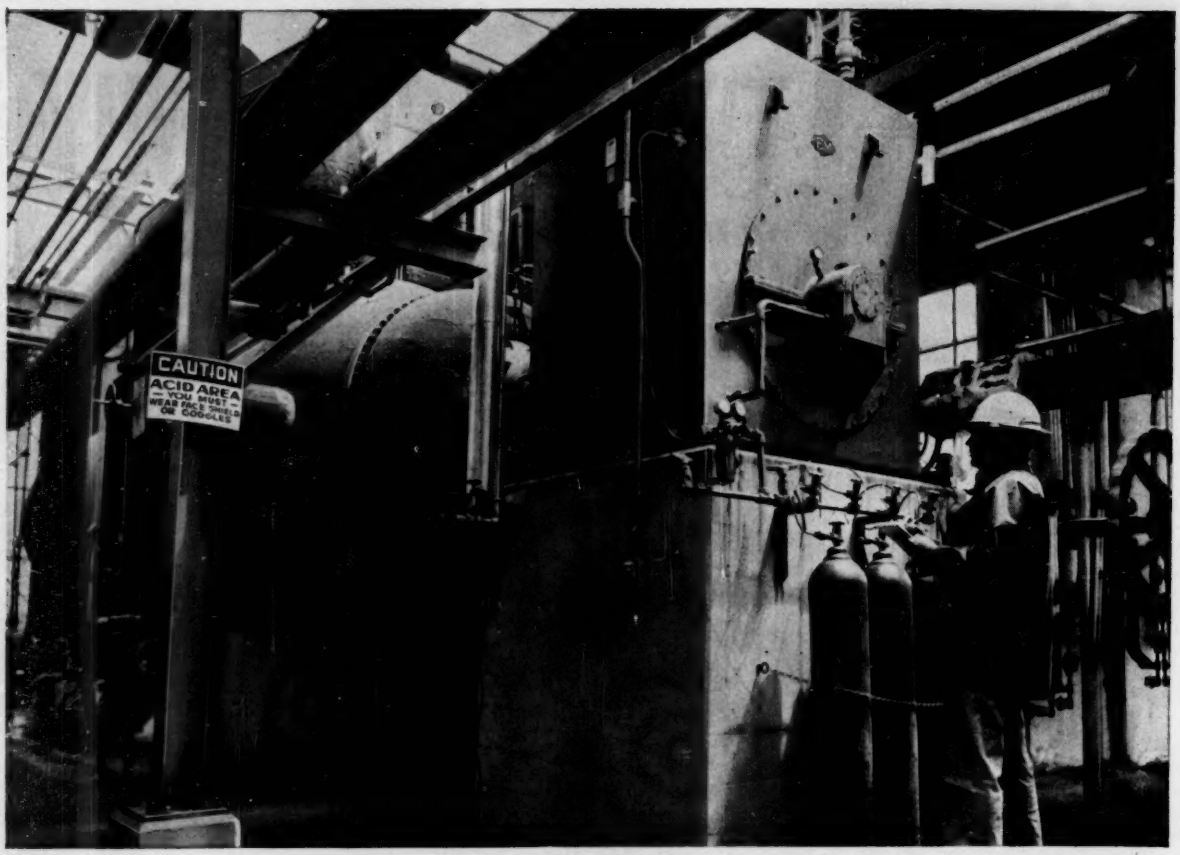

E-M TEIGF 400 hp, 585 rpm, 4600 v Squirrel-Cage Induction Motor driving contactor at Aurora Gasoline Company's Detroit refinery.

E-M's TEIGF Motor Provides Built-in Protection in Hazardous Area

"Protection for safe, reliable operation in an atmosphere of olefinic hydrocarbons and corrosive sulfuric acid."

This was the prime feature which prompted petroleum engineers at Aurora Gasoline Company to choose an E-M TEIGF (Totally-Enclosed Inert-Gas Filled) Custom-Tailored Motor to drive a large contactor at their Detroit refinery's new alkylation plant.

Here's how this built-in protection is assured in E-M's TEIGF Motor:

A low but positive pressure within the motor enclosure keeps dangerous, harmful gases out. Inert gas (nitrogen) pressure is maintained inside the enclosure at 1 to 2 inches of water above atmospheric . . . thus the motor always operates in a harmless atmosphere all its own, unaffected by ambient conditions. This means protection against the possible twin dangers of explosion and internal corrosion.

The E-M TEIGF Motor provides protection against expensive operation, too. Gas loss is lower than commercial standards. Special oil-pressure gas seals provide positive seal at shaft bearings. Seals are virtually non-wearing.

Motor maintenance is minimum . . . the motor in the photo above operates 24 hours per day, with a scheduled maintenance shutdown only once every twelve months.

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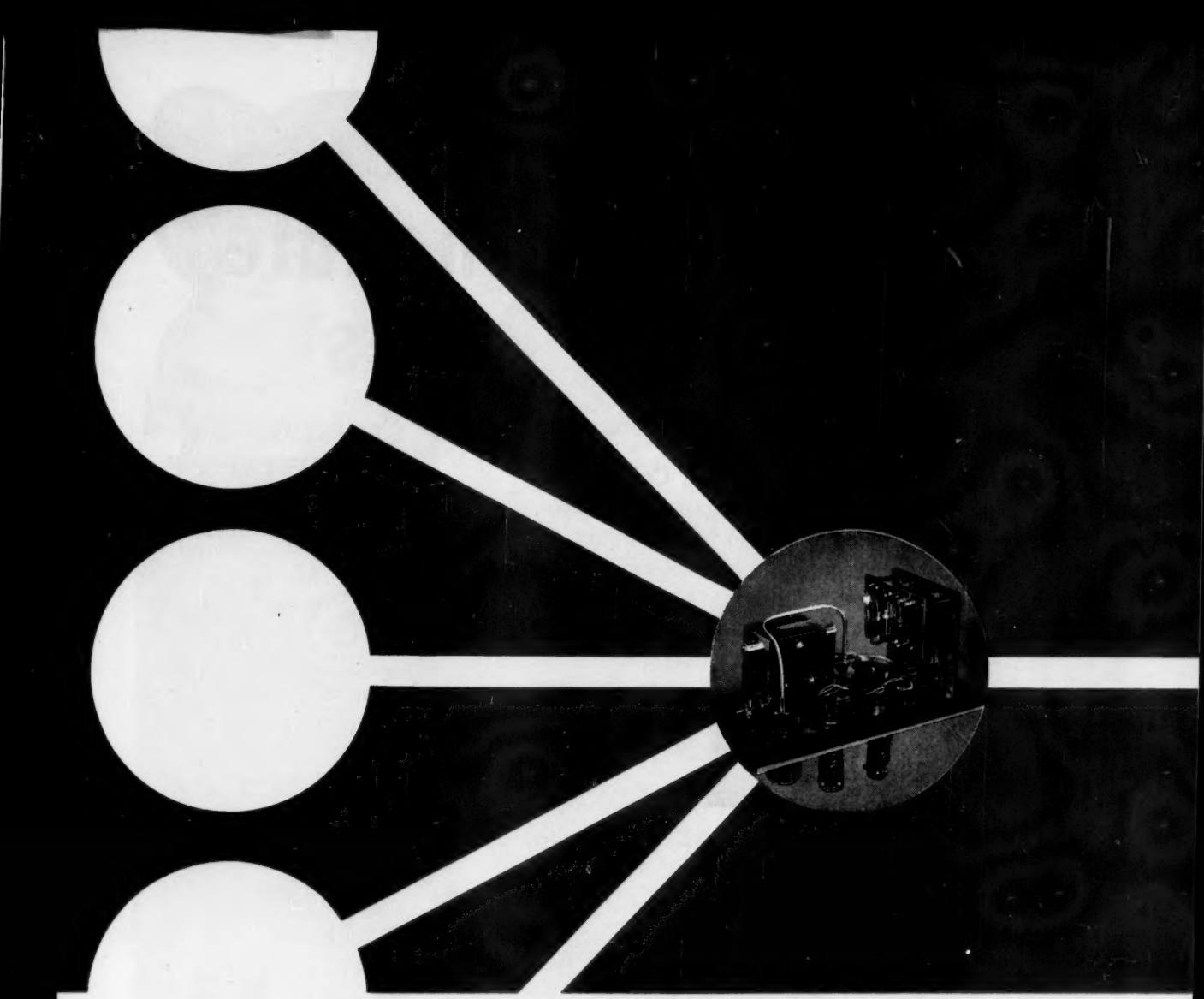

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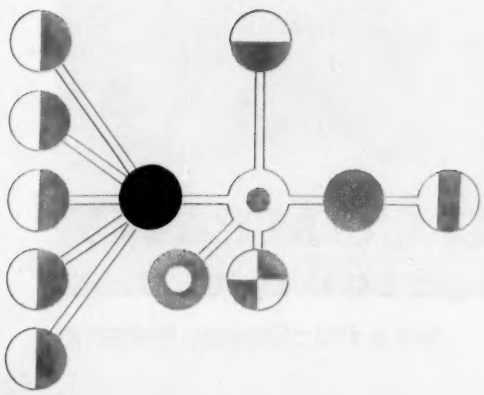
Transducers are part of the complete PowrMag line, which includes all the components for complete control systems. All solid-state electronic, the system has been engineered to meet rigid specifications of performance, reliability and compatibility in original or replacement instrumentation applications. For more information, write or phone HAGAN CHEMICALS & CONTROLS, INC., Hagan Center, Pittsburgh 30, Pa. Telephone WAlnut 2-3737.



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Nash Compressors Tame "Hard-to-handle" Corrosive Gases

The reasons for the success of Nash Compressors in handling "dirty" and corrosive gases are simple. First, Nash Compressors have no internal parts in wearing contact, or requiring close tolerances and internal lubrication. Second, because of the Nash operating principle, a variety of liquids can be employed as the compressant medium, protecting the interior from corrosive action. Third, the pump casing may be fabricated from a variety of special metals and alloys. That is why Nash Compressors take these rugged jobs in stride.

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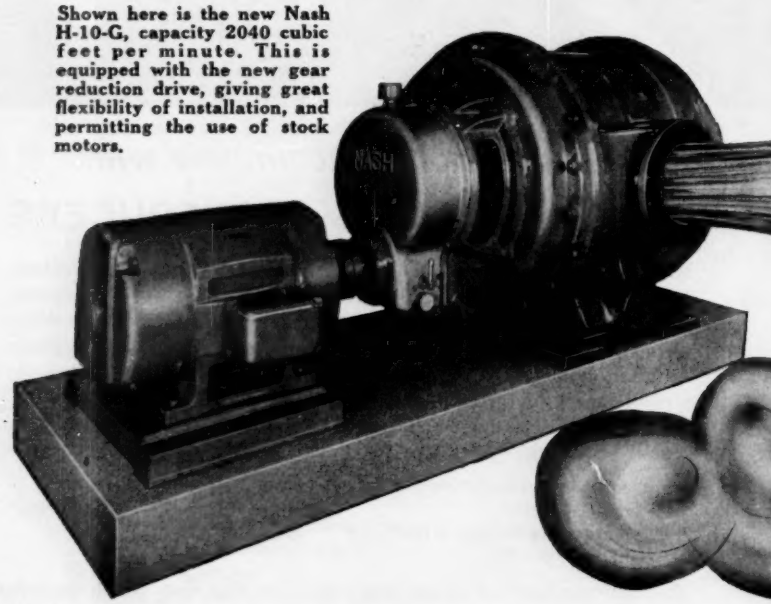
HEXANE
HELIUM
HYDROGEN
HYDROGEN SULPHIDE
NITROGEN
OXYGEN
PHOSPHOROUS PENTOXIDE
SULPHUR GAS
VINYL ACETATE
VINYL CHLORIDE
AND MANY OTHERS

Shown here is the new Nash H-10-G, capacity 2040 cubic feet per minute. This is equipped with the new gear reduction drive, giving great flexibility of installation, and permitting the use of stock motors.



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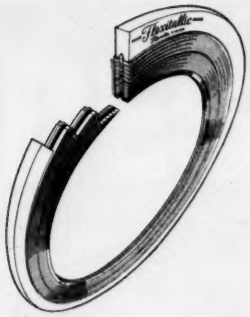

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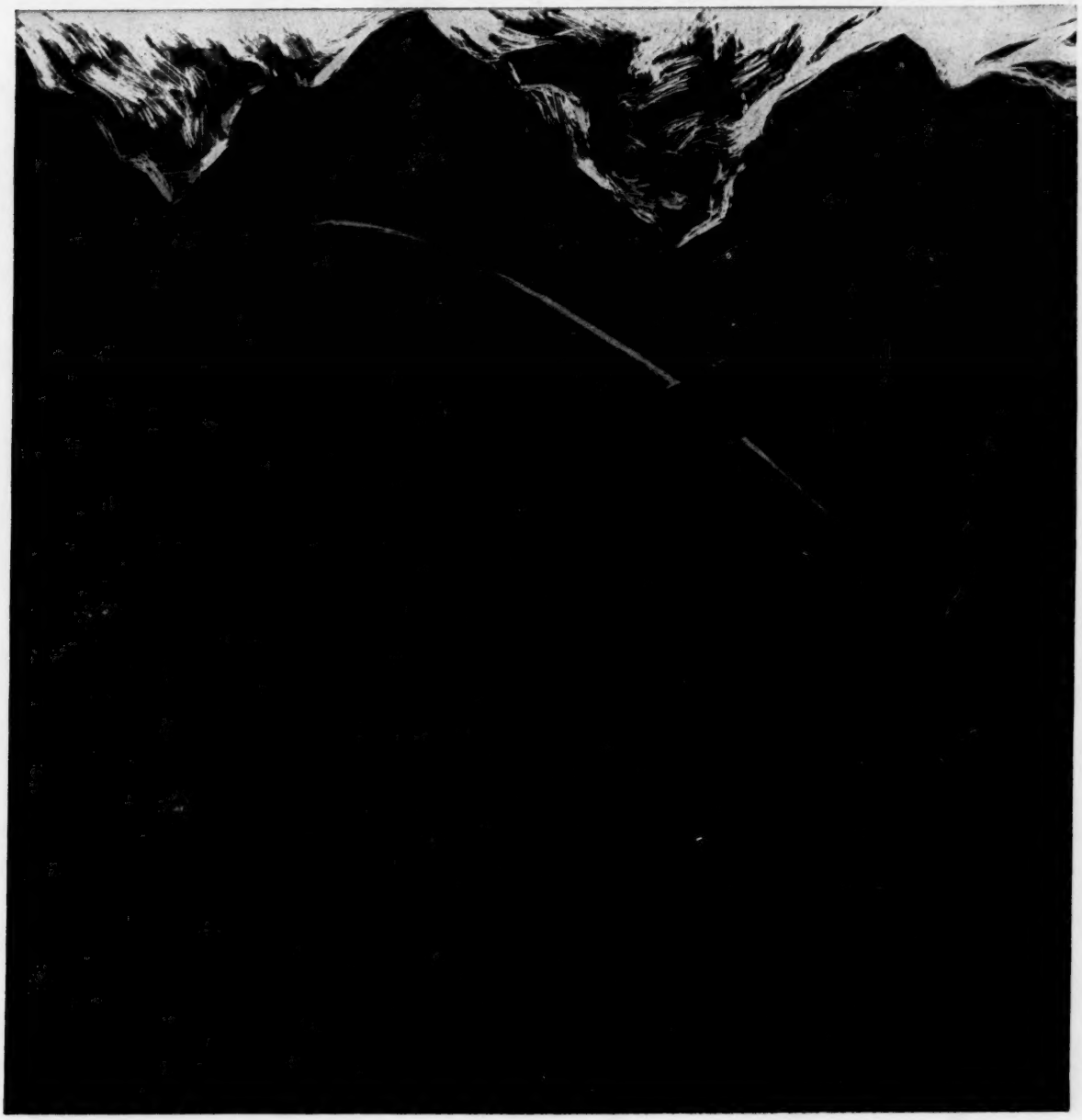

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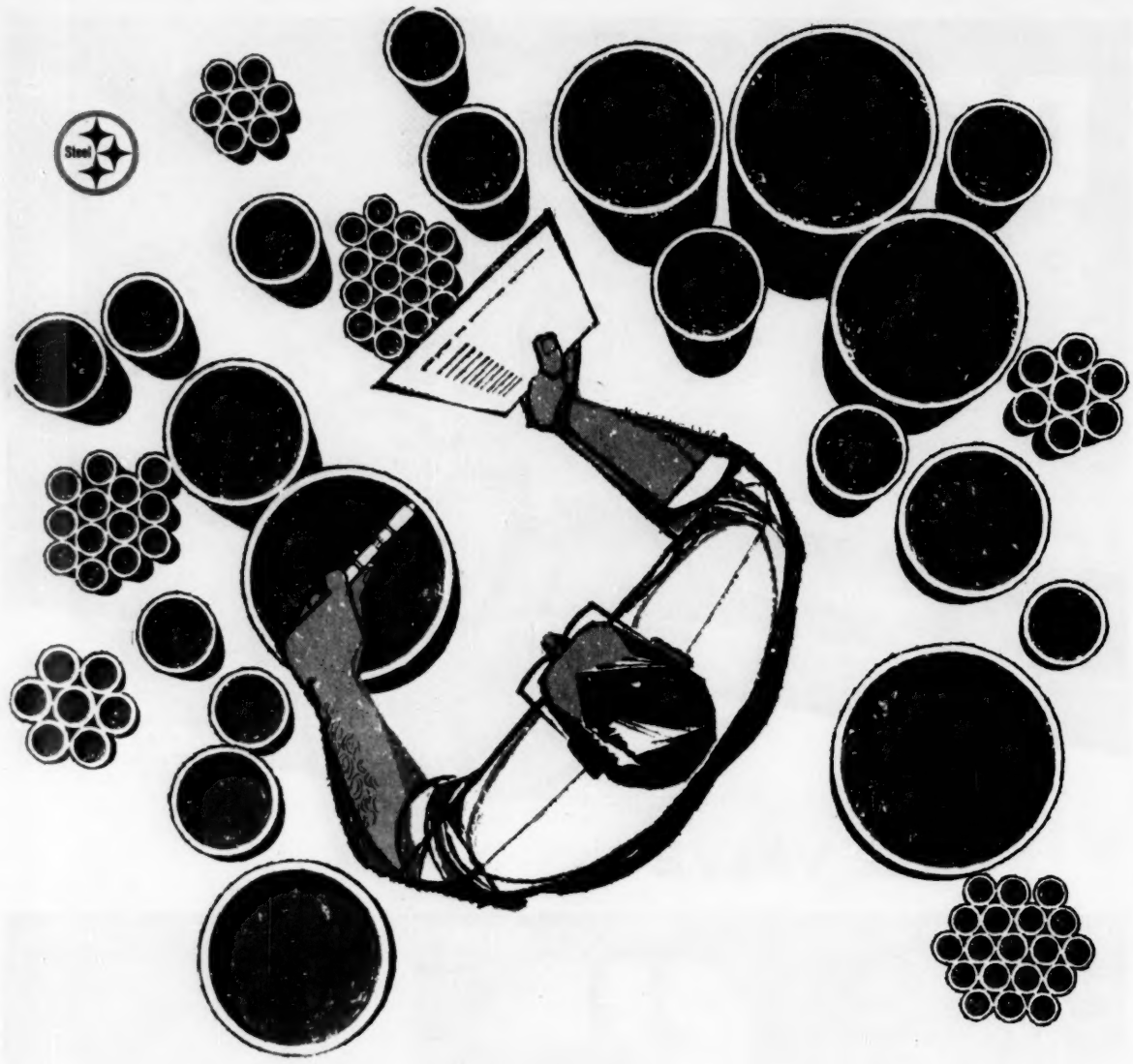

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WELDED STEEL TUBE INSTITUTE, INC.

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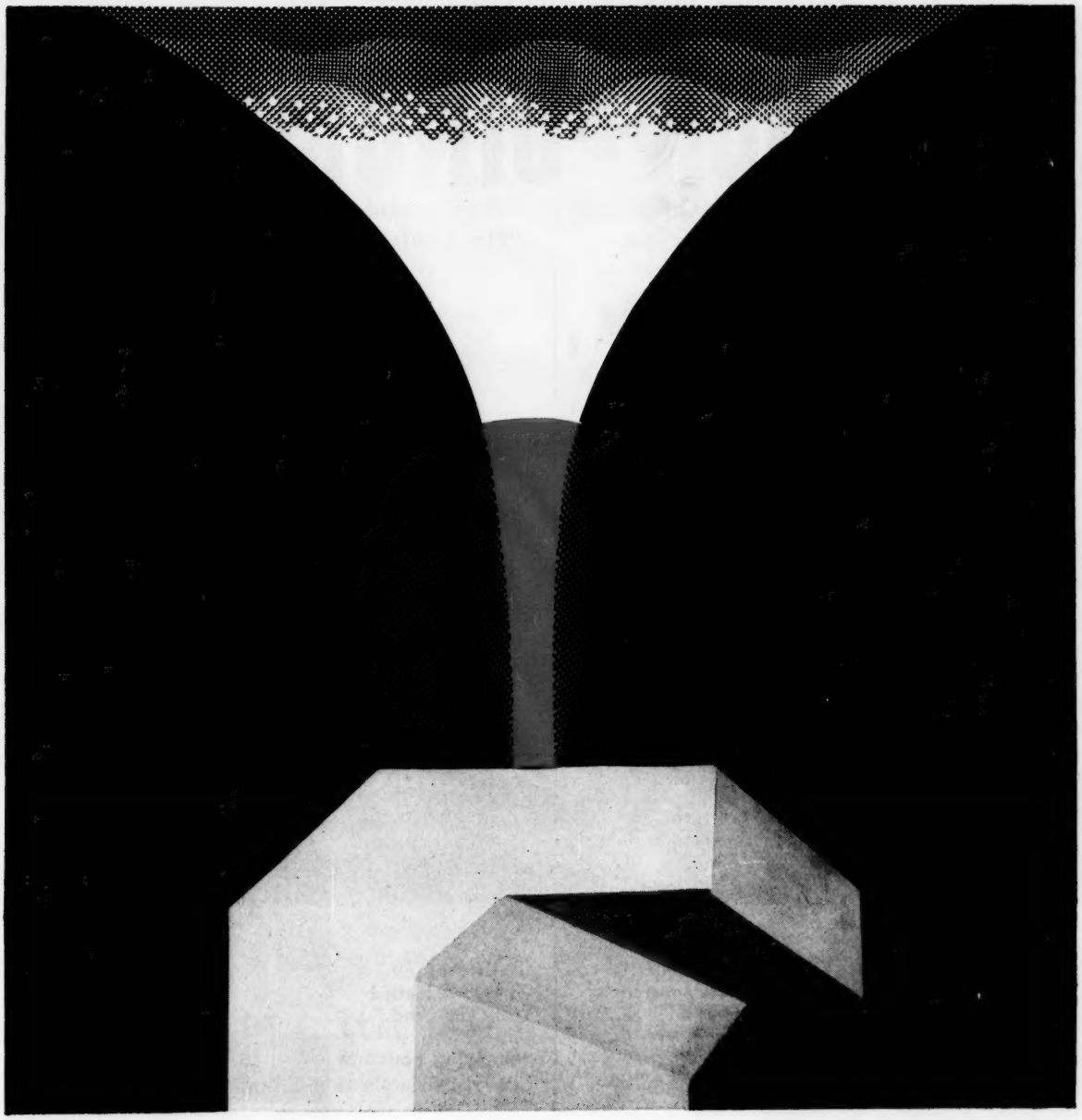

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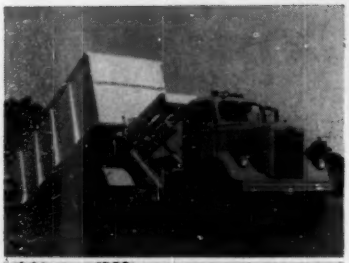
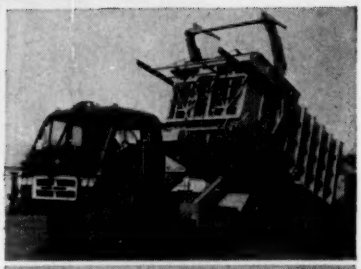


Besides serving DINOMASTER, the DINOSAUR picks up huge loads in big capacity containers . . .

DINOSAUR picks up DINOMASTER hydraulically for refuse container service.



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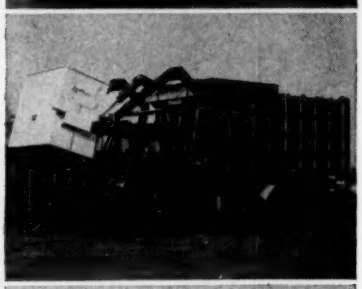

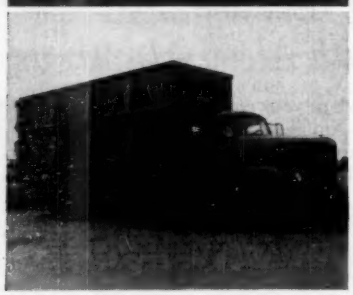

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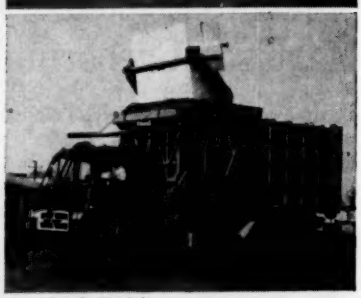

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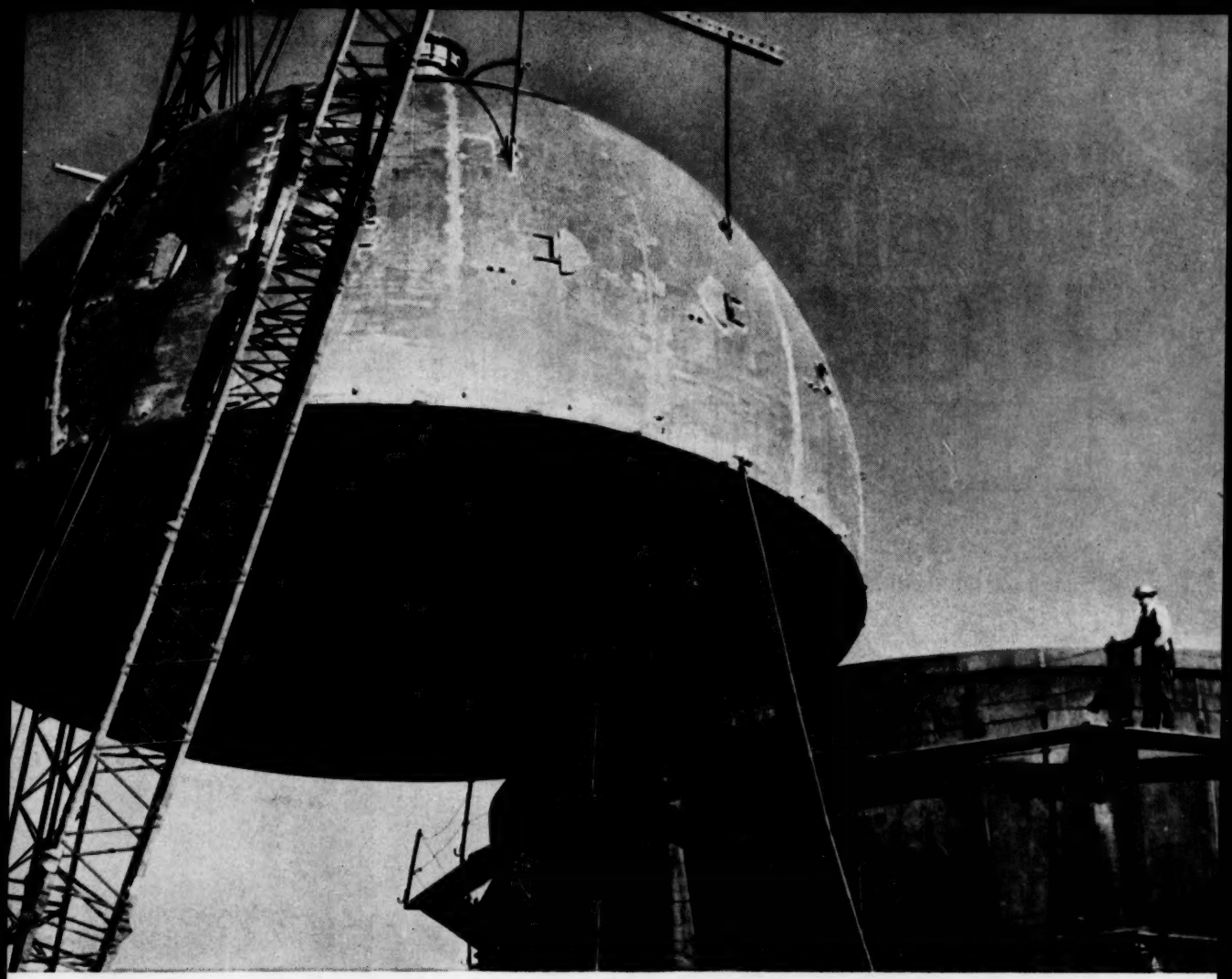


The colder the storage, the stronger the tank ...it's made with REYNOLDS ALUMINUM

Aluminum is one of the lowest-cost metals with a *higher* impact strength at low temperatures. That's why so much Reynolds Aluminum is used in tanks, vessels, piping, and equipment for cryogenic processes. Aluminum's yield strength, tensile strength, and percentage of elongation all *improve* at low temperatures—even near absolute zero!

In addition, the light weight of aluminum lowers fabrication and erection costs. Aluminum is easy to weld, and its high reflectivity protects volatiles from the sun's radiant heat. And it will not rust or contaminate. For complete literature file, call your Reynolds office, or write *Reynolds Metals Company, P.O. Box 2346-CJ, Richmond 18, Virginia.*

REYNOLDS ALUMINUM FOR CHEMICAL PROCESSING

Strong, Lightweight Structurals

Clean, Low-Maintenance Jacketing

Low-Cost, Corrosion-Resistant Process Pipe

Watch Reynolds TV show "Harrigan & Son", Fridays; also "All Star Golf", Saturdays—ABC-TV

a new line of Bulletin 709 motor starters by ALLEN-BRADLEY

- smaller size
- greater interrupting capacity
- even more millions of trouble free operations
- more wiring room
- elegant styling
- A-B "quality" throughout

A "family" of 7 starter sizes . . . each one entirely new

greatest advance in motor control in 30 years

In appearance . . . in performance . . . in physical size and weight . . . these Allen-Bradley Bulletin 709 solenoid starters are *completely new in every way!*

NEW COMPACTNESS. Size reductions are so drastic you'll hardly believe your eyes. The tables below will give you some idea of how the new line of Bulletin 709 starters compares with the old.

A TREMENDOUS INCREASE IN LIFE—both mechanical and electrical. All of these new starters are good for many more millions of trouble free operations.

NEW PATENTED MAGNET. For its weight and size, the most powerful magnet used on motor control. Its short, cushioned stroke assures long contact life. A new, permanent air gap prevents any possibility of magnetic sticking. "Snap action" guarantees positive contact opening and closing.

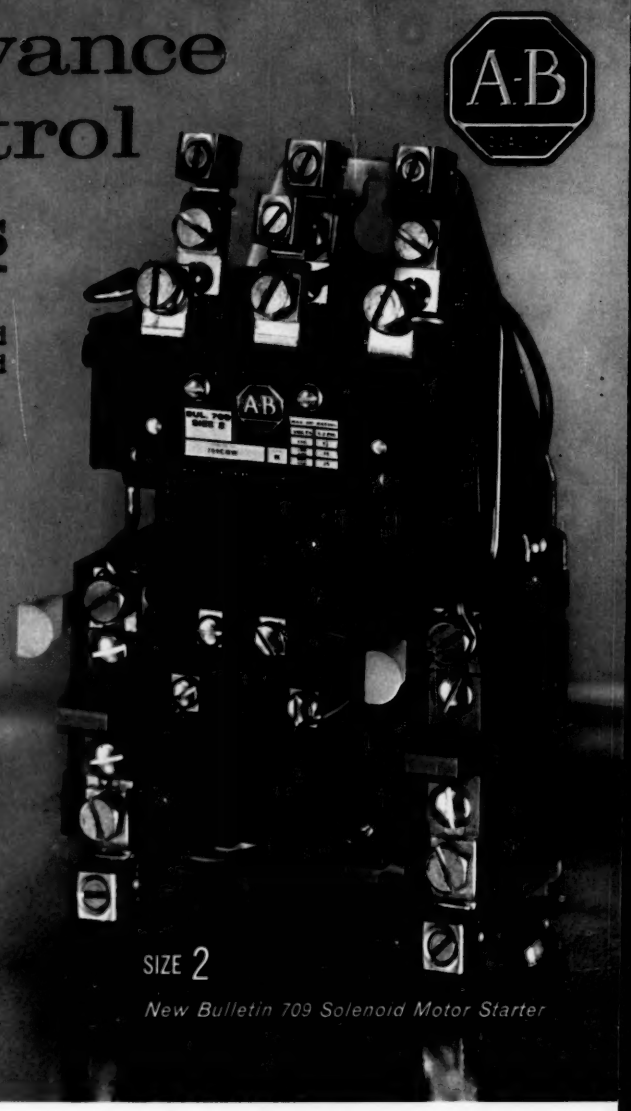
NEW MOLDED COIL. Impervious to atmospheres that could cause trouble, and also protected against mechanical damage. All coils are easily removed—from the front of the starter.

NEW CONTACTS. New double break contacts of cadmium oxide silver resist welding . . . close and seat firmly without sliding or wear-causing motion.

NEW OVERLOAD RELAYS. Not only "trip-free" but also "tamperproof," to reliably protect motor and machines. Of course the new relays were designed to use the old Bulletin 709 heating elements which you have in stock.

NEW ENCLOSURES. Completely restyled by Brooks Stevens—and so modern. They are a sales asset on any type of modern machine or industrial installation.

BETTER WRITE FOR MORE INFORMATION ON THIS REVOLUTIONARY NEW BULLETIN 709 STARTER!



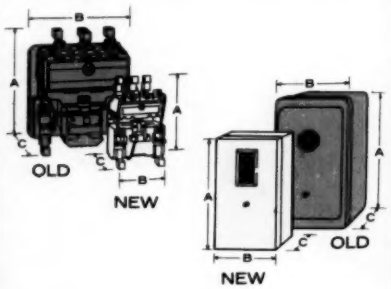
SIZE 2

New Bulletin 709 Solenoid Motor Starter

CHECK THE "NEW" WITH THE "OLD" BULLETIN 709 DIMENSIONS

The wiring room in the new enclosures will delight the electrician.

Starter Size	OPEN TYPE STARTERS					
	NEW			OLD		
	Height A	Width B	Depth C	Height A	Width B	Depth C
00	3⅝	3⅞	3⅝	—	—	—
0	5⅞	4⅛	3 11/16	5⅝	4¼	3¼
1	6⅝	4½	3 11/16	5⅞	5	3¼
2	7¾	4⅝	3 11/16	10 1/16	5¾	4⅜
3	10¼	6¼	5⅞	12⅝	7¼	5⅞
4	11⅞	7⅛	6¼	16¼	12¾	6 15/16
5	14 13/16	9	6½	20	16⅛	8¼



Starter Size	NEMA 1 ENCLOSURES					
	NEW			OLD		
	Height A	Width B	Depth C	Height A	Width B	Depth C
00	7⅝	4⅞	4¼	—	—	—
0	9⅛	6 5/16	4⅜	7⅞	5⅝	4¼
1	10	6 13/16	4⅜	8 13/16	6⅝	4¼
2	12	7⅝	4⅜	14½	9	5⅞
3	16⅝	10⅜	7	19½	11⅜	6 15/16
4	22	11⅝	8	26 9/16	14 3/16	7 15/16
5	32 3/16	17 3/16	9⅞	41½	19 1/16	13 1/16

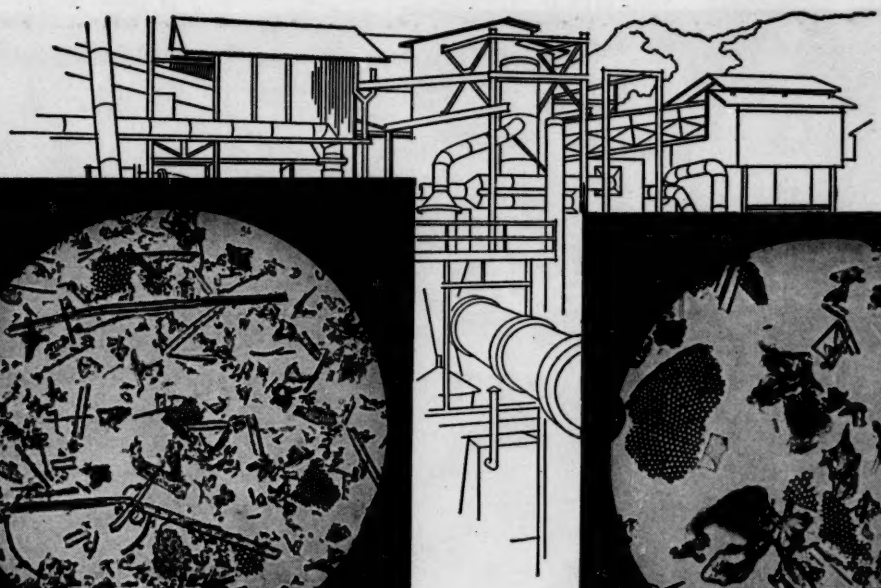
8-61-RM

ALLEN-BRADLEY

Member of NEMA

Quality Motor Control

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wisconsin



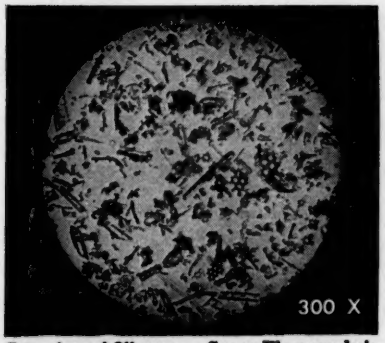
Milling and calcining equipment used for all Celite grades.

For high-clarity filtration of most liquids—use this specially milled diatomite, Hyflo Super Cel.

For filtration of larger suspended particles—Celite 545 combines maximum clarity plus faster flow rates.

In diatomites, Johns-Manville precision processing works for you

Constant uniformity in every grade of Celite assures consistent results, less down-time



For mineral filler use—Super Floss grade is made up of carefully sized fines air-floated off in the bag house.

Typical J-M bag house equipment.

AS THE MICROSCOPE SHOWS, each grade of Celite* diatomite has its own distinctive particle size distribution. Yet no matter where or when purchased, each remains uniform from bag to bag—your assurance of top production results with minimum down-time.

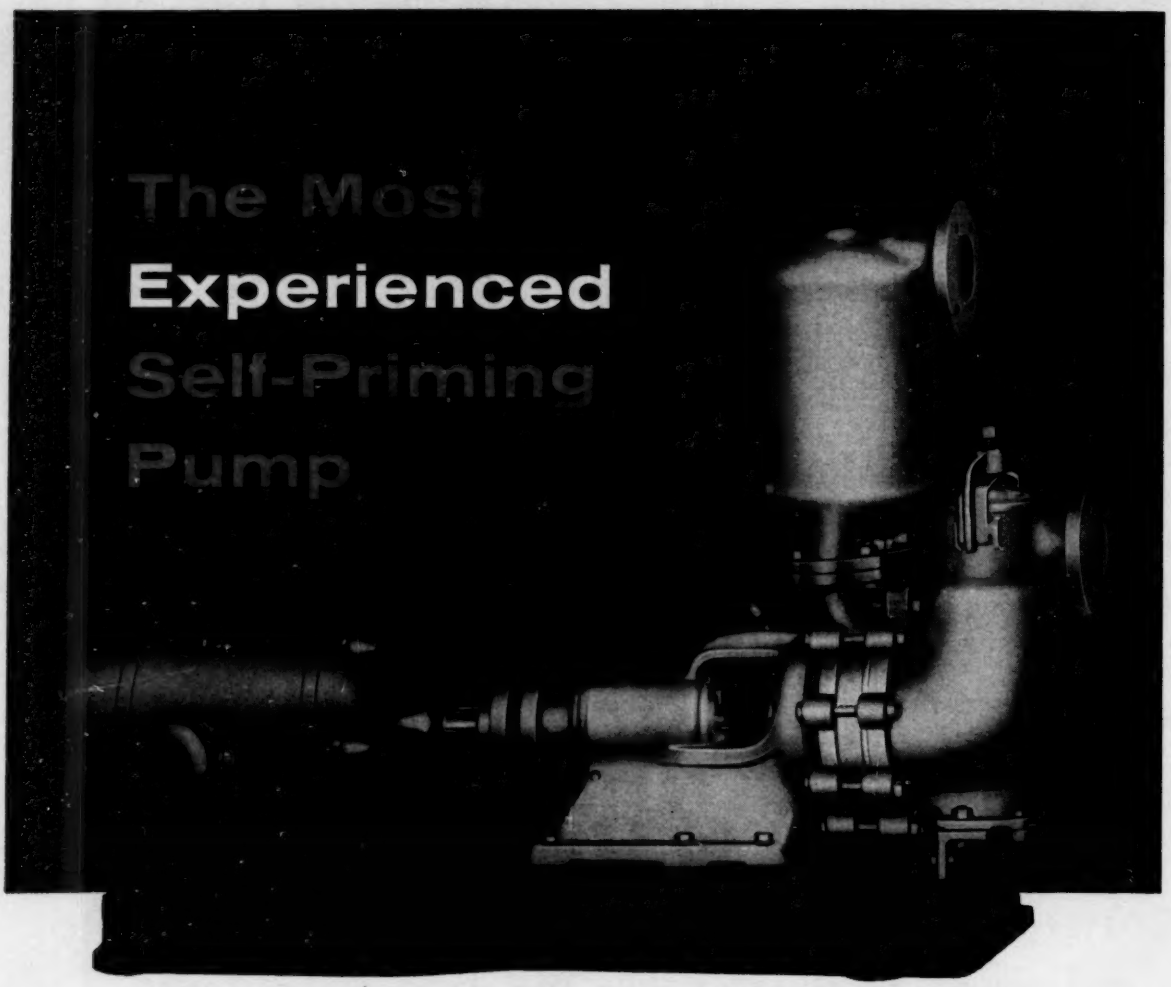
Three examples of flux-calcined Celites are shown here. Hyflo® Super Cel is widely used for filtration in many industries. It has just the right combination of coarse and fine particles to assure optimum clarity and flow rates. Celite 545, with a higher percentage of coarse particles, is used to achieve maximum clarity and faster flow rates with liquids that have larger suspended particles.

Super Floss, one of several bag house grades, has fine particle size distribution. A white powder, it is processed within very narrow tolerances (less than 1% retained on 325 mesh). It is a popular filler in fine products such as silver polishes.

Johns-Manville can precision-produce so many different grades of Celite because it mines the material from the world's largest and purest commercially available deposit. For assistance with specific filtration or mineral filler problems, talk to a nearby Celite engineer. Or write direct to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

JOHNS-MANVILLE



LaBour Type DPL as pictured here is the modern, improved counterpart of the first self-priming pump ever offered to the chemical industry. Nearly 40 years of experience in hundreds of plants all over the world have proved the reliability and efficiency of this unit to the satisfaction of a whole generation of engineers and operating men.

If you're looking for assured performance and dependable, trouble-free economy, you can play safe by specifying LaBour for your toughest jobs as well as for routine applications. Ask us for details.

ORIGINAL MANUFACTURERS OF THE SELF PRIMING CENTRIFUGAL PUMP

LABOUR

THE LaBOUR COMPANY, INC. • ELKHART, INDIANA
WHITE PIGEON, MICH. • LONDON, ENGLAND

POWELL PERFORMANCE PAYS OFF

Powell valve performance really pays off for the chemical industry. Take "reliability" for instance.

Powell reliability starts with good design features specifically tailored for chemical installations. For example, there is a deep stuffing box for an extra amount of special packing. And valve bodies are designed with full flow areas for maximum flow conditions and minimized pressure drop. Also, wedge discs are precision machined and fully guided to eliminate drag and wear of the seating surface as well as undue vibration.

You get thorough valve engineering like this—plus, industry's widest selection of valve materials, both ferrous and non-ferrous, so that Powell valves can withstand virtually any problem of corrosion, erosion, temperature or pressure. Whatever your valve requirements—look to Powell.

All this adds up to reliability that gives a performance pay off to you. Get the full story from your nearby Powell Valve distributor, or write The Wm. Powell Company, Cincinnati 22, Ohio.

115th year of manufacturing industrial valves for the free world

POWELL CORROSION-RESISTANT **VALVES**

THE WM. POWELL COMPANY CINCINNATI 22, OHIO

Always before, this material had to be blasted. Then they bought a Michigan Tractor Shovel. It ended the trouble and

SAVED $34,000 per year

Ability of their Michigan Tractor Shovel to dig a material which always before had to be blasted is saving an estimated $34,000 per year for Davison Chemical Co, Bartow, Florida.

Together with its digging power, the Michigan also has proved mobile enough to work quickly in the same tight quarters as the smaller loaders it replaced.

The material being handled is triple super-phosphate—manufactured, stored and cured at this plant for at least four weeks. The Michigan is a Model 85A, 9000 lb lift capacity equipped with 1¾ yd bucket and replaceable bucket teeth. Its savings have been fourfold . . .

ONE, because the 96 hp Michigan can effectively load the hard-set TSP, Davison has eliminated all blasting.

TWO, the plant has traded in one of the two ⅞ yd tractor shovels previously used to handle the blasted material, moved the second to another job. This transfer has resulted in substantial savings due to the Michigan's lower maintenance cost and greater capacity.

THREE, no less than *12 men* (on a 3-shift basis) *have been transferred to other jobs* . . . 3 tractor shovel operators, 6 drillers, 3 dynamite handlers.

FOUR, with the elimination of blasting has come the elimination also of building repairs. No more are holes blown in the sides and top of the 25,000 ton capacity curing and storage shed.

40 to 45 loads moved hourly

Photo above shows typical operation. Like most loads, this one totals about 1¾ cu yds, 1800 to 2000 lbs. In seconds, the Michigan will turn, drive 25 to 150 ft, and feed the crusher hopper. Output, loaded by hopper conveyor into railcars, averages 40 to 45 Michigan bucket loads, 36 to 45 tons per hour.

Try Michigan on your job

Michigans, of course, can't *always* eliminate blasting. But they do have almost unbelievable breakout force (plus maneuverability, plus unexcelled dependability). We'll be glad to give you the proof of a demonstration. Seven 4-wheel-drive, two 2-wheel-drive models to choose from.

Michigan is a registered trademark of

CLARK EQUIPMENT COMPANY
Construction Machinery Division

CLARK EQUIPMENT

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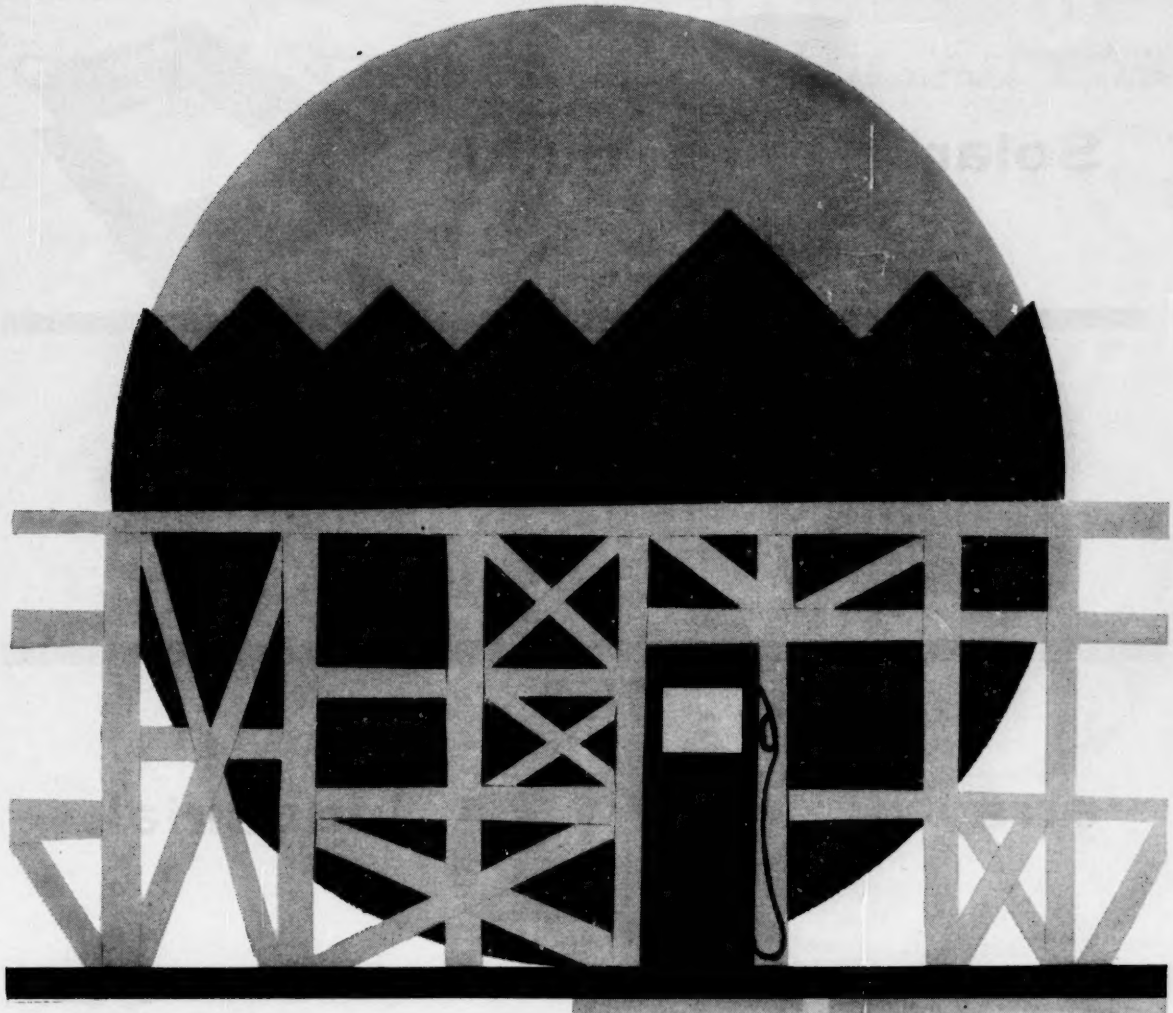
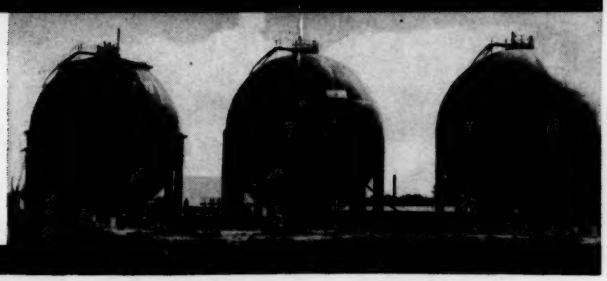


FOAMGLAS® Insulation works for SOHIO



EVIDENCE: From 1949 through 1953, Standard Oil of Ohio constructed four huge electric desalting spheres at plants in Cleveland, Lima and Toledo, Ohio. Exact temperature control (200°F.-230°F.) was vital for this process. That's why Sohio chose FOAMGLAS Insulation.

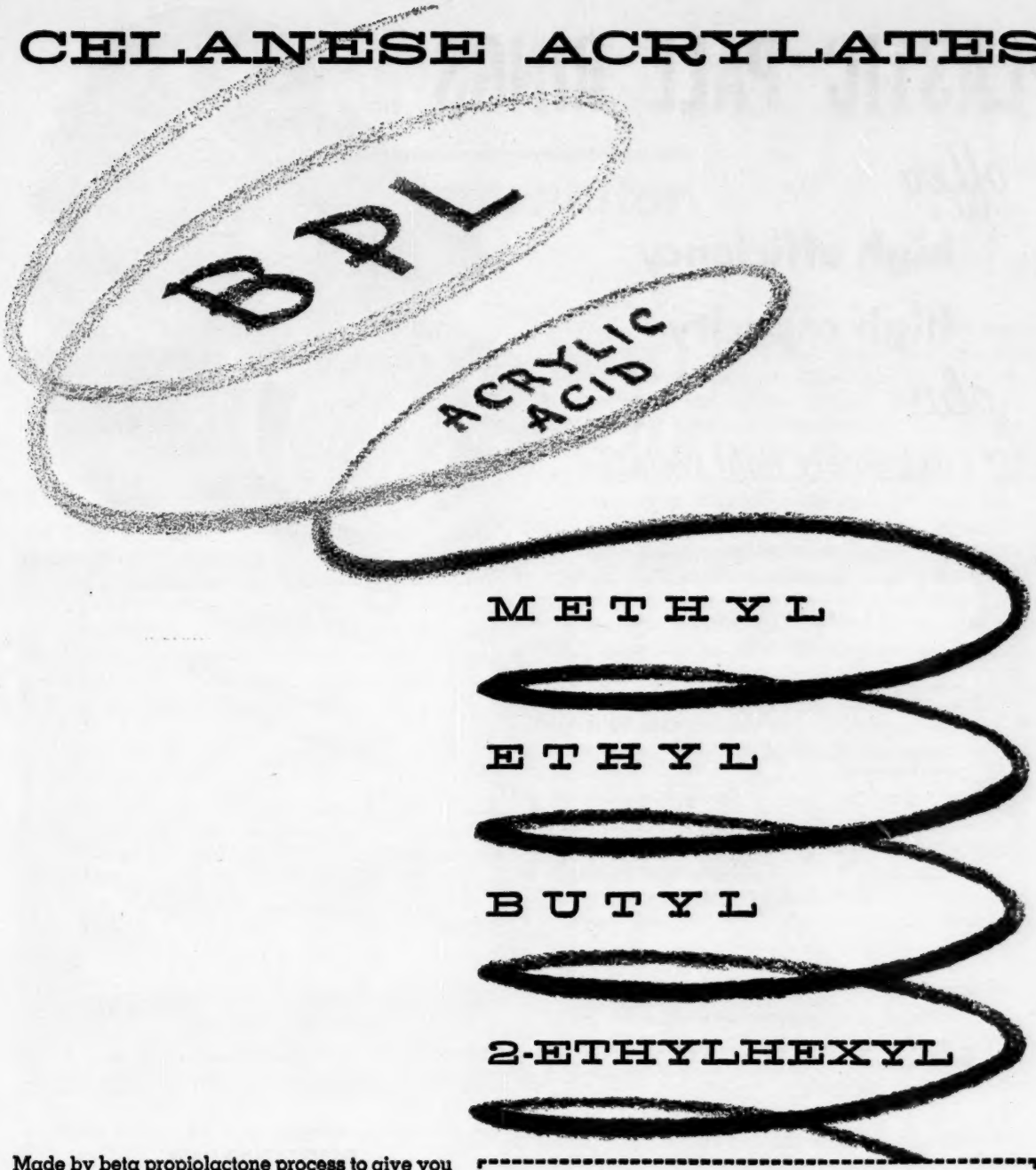
The long-lasting insulation performance necessary to maintain these critical temperatures was made possible because of the closed glass cell structure of FOAMGLAS. It stays dry! The permanency of insulation meant still more to Sohio. Because of the inaccessibility of the 27'6" spheres, insulation failure would involve astronomic replacement and maintenance costs. And using FOAMGLAS provides an important extra benefit in this petroleum application: it's incombustible.

Investigate FOAMGLAS for your toughest insulation requirement—whether it is tanks, equipment, piping, walls or roof. Write for our Industrial Insulation Catalog and a copy of the detailed Sohio Fact Sheet. Pittsburgh Corning Corporation, Dept. H-41, One Gateway Center, Pittsburgh 22, Pa. In Canada: 3333 Cavendish Boulevard, Montreal, Quebec.

Pittsburgh Corning makes available a complete line of accessory materials for use with FOAMGLAS Insulation. Write for Data Sheets.

PITTSBURGH PC CORNING

CELANESE ACRYLATES



Made by beta propiolactone process to give you unexcelled purity of product. Send for technical literature. Celanese®

Celanese CHEMICALS

For a complete description of Celanese Chemicals, Please refer to our Product Index in current issues of *Chemical Materials Catalog* or *Chemical Week Buyer's Guide.*

Celanese Chemical Company is a Division of Celanese Corporation of America.

Celanese Chemical Company, Dept. 553-D
180 Madison Avenue, New York 16, N. Y.

Please send technical literature on Celanese Acrylates.

NAME_____ TITLE_____

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PLASTIC PALL RINGS

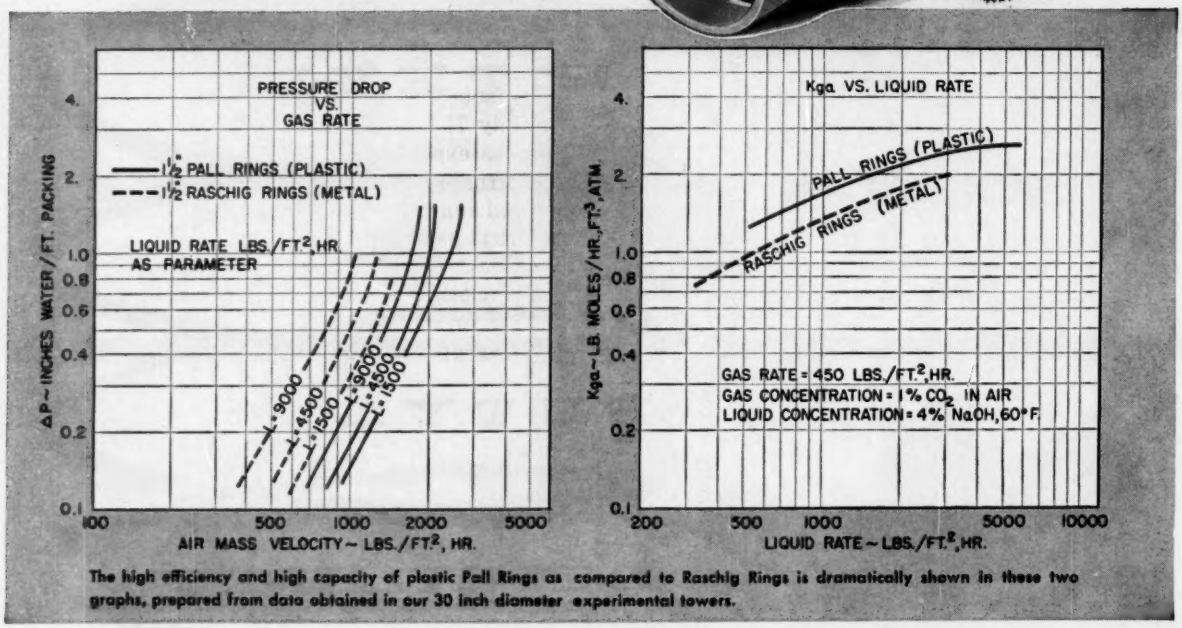
offer

high efficiency

high capacity

plus

extremely light weight



The high efficiency and high capacity of plastic Pall Rings as compared to Raschig Rings is dramatically shown in these two graphs, prepared from data obtained in our 30 inch diameter experimental towers.

Weighing less than 5 lbs. per cu. ft. (as opposed to 23-27 lbs. per cubic foot in metal), plastic Pall Rings permit substantial economies in tower construction costs.

Plastic Pall Rings are injection molded in four sizes: ⅝", 1", 1½", and 2" in polypropylene (and on special order in rigid PVC or polystyrene). The sectioned wall projections, characteristic of the Pall Ring design, form a rigid cross-web in the ring for added structural strength.

Polypropylene possesses excellent resistance to strong alkalies, organic and inorganic acids including hydrofluoric acid and fluorine compounds at temperatures as high in some cases as 250°F.

ENGINEERING DATA

Are you on our mailing list to receive reports from our continuing engineering research program into packed tower performance? If not, a note on your letterhead will bring them promptly. Address Dept. CE-461, U. S. Stoneware, Akron 9, Ohio.

Process Equipment Division

U. S. STONEWARE

AKRON 9, OHIO 253-G

Top news stories and what they mean to CPI technical decision-makers

Chementator

Tyrex wins latest tire-cord bout. Nylon's next move: a price cut?

The constant warfare between Tyrex (rayon) and nylon for the new-car tire market is entering another phase. Winner to date: Tyrex.

An executive of a leading tire company tells *CE* that nylon is dead for the time being unless its price is made more competitive with Tyrex. And this could not happen in time to affect the decision for the 1962 models.

A nylon price cut of 1¢/lb. means a saving of $600,000/yr. to auto and tire makers, and they make it quite plain that cost cutting would certainly put nylon back in competition for original equipment. The next move is up to the nylon makers (especially pace-setter Du Pont) to decide whether the added business is worth the slimmer profit margin.

Here is how Tyrex has stayed on top: Chevrolet equipped 25% of its early 1960 models with nylon tires but stopped soon after it began getting complaints about flat-spotting (it's called "morning sickness" in the tire trade). At the same time that nylon was having these difficulties, rubber companies came up with a two-ply tire (instead of four plies) that has caught Detroit's fancy. Advantages of the new construction include a 4% lower price, softer ride, slight increase in fuel economy and greater strength at high speeds. As things now stand, a two-ply Tyrex tire contains 2.5 lb. of yarn costing $1.25. An equivalent nylon tire contains 1.7 lb. of yarn costing $1.55.

Steel mills try cloth filters for smoke control, may save millions

Four San Francisco Bay steel mills are engaged in a $250,000 experiment that they hope will eventually save them much more than this. They are installing a full-scale nonshaking bag house on the stack of one of the open hearth furnaces at Bethlehem Steel's mill.

If successful, the glass-cloth bag-filter unit will trap 75 lb./hr. of dust, slash smog-producing stack emissions by more than 99%. High-temperature bag houses (*Chem. Eng.*, Jan. 25, 1960, p. 53) have never been tried in this service before. But the Bay area mills are faced with a 1963 deadline to clean up stack gases, feel that the bag house may offer the cheapest way out.

Electrostatic precipitators have been the usual solution when steel mills installed dust-control equipment, although venturi scrubbers have been winning increasing acceptance. Industry sources predict that the bag house will cost only 70% as much as a precipitator—if it works as expected.

Furnace on which the bag house is being installed runs entirely on cold scrap. Gases from furnace at 1,200 F. will cool to 55 F. before entering filters. Major factors to be determined: life of the cloth bags, amount of pressure drop, whether or not bags can be cleaned by merely reversing pressure. Results should be known in nine months.

If the test fails, the mills will be forced back to more conventional—and costly—equipment to comply with the air pollution regulations.

New technique for metal powders: instant liquid-phase reduction

A novel process that accomplishes *in situ* reduction of metals in solution has been developed by Micronized Metals, Inc., a small company in Long Island City, N. Y. Possible applications for the method: making metal powders, alloys of immiscible metals, dispersions of nonmetals in metals, one-shot catalysts.

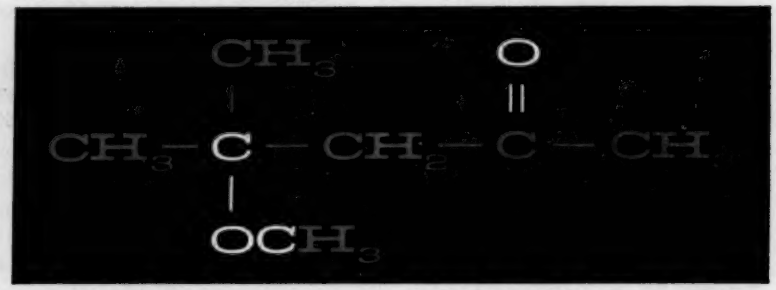
Key to the process: composition of the undisclosed solvent used to accomplish the reduction. Salts of the metal to be produced are dissolved in the solvent, then the entire mass is heated to around 215 F. At that temperature, an exothermic reduction reaction is triggered, raising the temperature of reactants to over

BULLETIN:

Comparative data on Shell Chemical's high boiling Pent-Oxone* solvent promises lower costs on vinyl lacquers

Pent-Oxone solvent is a keto-ether. It is a remarkable new compound of this class of chemical which gives you double solvent action plus high diluent tolerance for use with a wide range of lacquer resins.

Read how Pent-Oxone solvent compares with other high boiling vinyl solvents in evaporation and viscosity, what it costs, and where it is finding new applications in and out of the coatings industry.



Solvent action in glycol ethers comes from the COC ether linkage. In ketones, the double bond oxygen does the work. Shell Chemical's Pent-Oxone is the only commercially available solvent with *both* these functional groups.

BECAUSE it combines the solvent properties of ketones and glycol ethers in one molecule, Shell Chemical's new Pent-Oxone gives you greater solvent potential than any other type of high boiler.

This potential can often save you money. In vinyl lacquers, Pent-Oxone can replace high boilers costing 40¢ to $1.10 more per gallon.

Comparative evaporation data

Pent-Oxone is in the high boiling class with an evaporation rate comparable to cyclohexanone and EGMEE acetate. Comparisons with cyclohexanone and isophorone in seconds are as follows:

Per Cent evap.	cyclo-hexanone	Pent-Oxone	iso-phorone
10%	180	231	2600
30	560	715	8300
50	940	1200	14200
70	1330	1680	20600
90	1720	2175	27600
95	1825	2310	29500
100	2120	2450	34000

Comparative viscosity data

The following viscosity comparisons are taken after one hour on a 50/50 solvent/toluene mixture with the indicated Vinylite** resin:

10% VYNS-3	Pent-Oxone	93 cps.
	cyclohexanone	54 cps.
20% VMCH	Pent-Oxone	125 cps.
	cyclohexanone	142 cps.
	isophorone	260 cps.
20% VYHH	Pent-Oxone	310 cps.
	cyclohexanone	232 cps.
	isophorone	285 cps.
20% VAGH	Pent-Oxone	500 cps.
	cyclohexanone	320 cps.
	isophorone	405 cps.

With VAGH/Pent-Oxone solvent, viscosities rise with time. This can be overcome by using 50/50 Pent-Oxone solvent/cyclohexanone as the active solvent. Such a mixture would save you 55¢ per gallon against using cyclohexanone alone.

Better odor, lower cost, many uses

The price of Pent-Oxone is 17.5¢ per pound delivered in tank cars. It can tolerate up to 70% diluent in vinyl chloride/vinyl acetate copolymer solutions. It has a better odor than other vinyl solvents and is proving valuable in vinyl adhesives as well as acrylic lacquer thinners.

In nitrocellulose lacquers, Pent-Oxone retards blush, dries in reasonable time. It acts as a coupling agent in sludge removing compounds.

Complete data and samples

For samples and information, including complete graphs on viscosity and evaporation, write or call any of Shell's 9 Industrial Chemicals Division offices, or write Shell Chemical Co., 110 W. 51 St., New York 20, N. Y.

Do it today. Start investigating Pent-Oxone's remarkable keto-ether action for yourself.

*Trade mark, Shell Chemical Company
**Trade mark, Union Carbide Corp.

A Bulletin from

Shell Chemical Company

SHELL

Industrial Chemicals Division

2,000 F. in a fraction of a second. The solvent is vaporized, leaving metal powder or sponge in the reaction vessel.

One of the more promising products of this process has been a fine disperson of alumina in lead, formed by dissolving aluminum salts in the solvent along with lead. Metallic lead is produced in the reaction, but the aluminum comes out as submicron particles of Al_2O_3 in the lead matrix.

Dispersed alumina is claimed to increase lead's mechanical strength without impairing the metal's corrosion resistance. The operation is said to add only 4¢/lb. to the cost of the lead. One possible application for the lead-alumina combination: unsupported lead pipe.

To form one-shot catalysts by this method, metals such as cobalt and molybdenum are put in a specially formulated solution, then crystallized and ground into powder. The powder is then injected into the reactant gas stream and heated to the triggering temperature. The catalyst supplies heat to the reaction as well as furnishing a large catalyzing surface. Firm has produced ketones in this fashion, but emphasizes that this method is still in the research stage.

Latest government statistics show that freshman engineering enrollment leveled out at about 67,600 during 1960, the first time in three years that there was no decline. But, by contrast, total first-time college enrollment was up 12.4%, while freshman enrollment in chemical engineering was under pressure, dropped 3.5%.

Electrolytic routes to TEL-TML bid to oust the lead-alloy process

Current interest in the gasoline additives business is focused on electrolytic processing. The goal is to find a cheaper way than the sodium-lead alloy process for making tetraethyl and tetramethyl lead.

Stepan Chemical had announced earlier this year that it was entering the TEL-TML business with a process licensed from the Italian firm Societa Lavorazioni Organiche Inorganiche. But Stepan recently changed its mind, said it had heard about a cheaper process. Some observers believe that it is an electrolytic route being piloted by the Nalco Chemical Co. in Chicago.

Electrolytic processes for TEL manufacture aren't new, but the economics have never seemed attractive. Germany's Karl Ziegler announced a way two years ago for making TEL by electrolysis of a sodium-aluminum alkyl-ethylene complex. And Ethyl Corp. says that it has done considerable research in this field—but it is keeping very quiet about its present interest in the commercial possibilities.

Two other factors affect the outlook for TEL-TML. When petroleum refineries are running at less than capacity—as they are now—there is pressure to use high-grade blending stocks rather than lead additives, to get desired octane. Too, Detroit is building more road octane into its engines while increasing the miles per gallon. All of these trends have combined recently to take a big bite out of additive sales.

The Swiss Lonza urea process will make its first appearance in North America in a $2.5-million fertilizer plant to be built on the Isthmus of Tehuantepec for a company owned mainly by Mexico's Pemex. Lummus Co. will design and engineer the facility.

Cyclohexane-to-caprolactam process relies on photochemical reaction

Japan's Toyo Rayon says it has achieved a goal that has eluded researchers in the U. S. and Europe: an economical photochemical process for producing caprolactam (the monomer for nylon 6) from cyclohexane. Firm claims that cost of monomer made via this route is less than 50¢/lb., is cheaper than material made from toluene (*Chem. Eng.*, Mar. 20, p. 94).

Japanese development comes at a time of mounting interest in caprolactam. Du Pont is currently completing shakedown runs of its 50-million-lb./yr. cyclohexane-based plant at Beaumont, Tex. Although the company has not revealed any details, its route is believed to involve a direct oxidation with nitric acid to cyclohexanone-oxime.

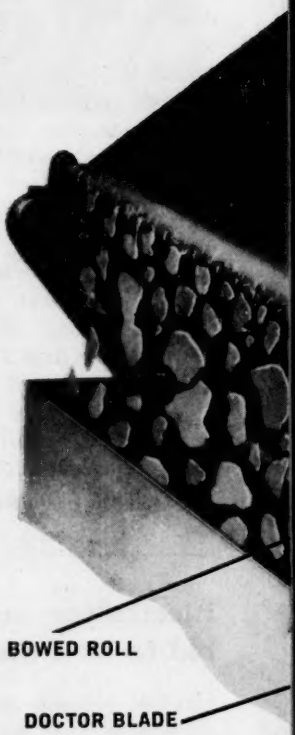
Allied Chemical, on the other hand, has shunned cyclohexane as a starting material and licensed the toluene-based Snia Viscosa process.

(Continued on page 84)

Now . . . a new answer to a wide

The D-O WEBTROL™

With fully automatic and continuous belt tracking system, providing the ultimate in web control



Developed out of the long experience of the Dorr-Oliver organization in building all types of filtration equipment, the new D-O Webtrol Filter provides a new opportunity for efficient handling of many problems not readily solved with conventional units.

It is particularly applicable where slurries with low solids content are handled, where cloth blinding is a problem and where desired filtrate clarity is not obtainable with usual types of vacuum drum filters. In many cases it can be used effectively where a pre-coat filter would normally be considered. Advantages are high capacity maintained over extended periods of use, simplicity of operation and superior washing ability.

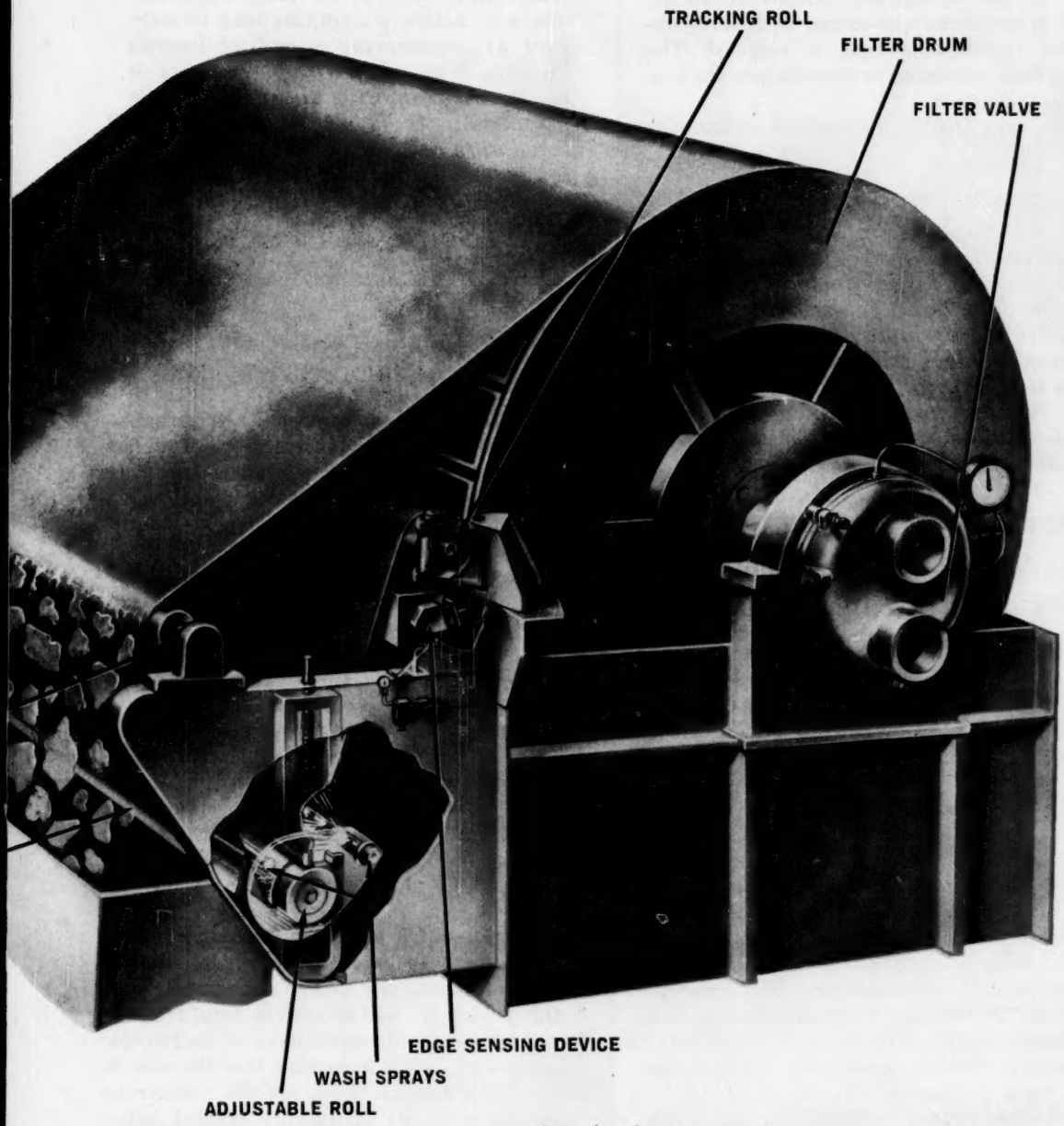
The D-O Webtrol Filter combines the basic principle of the Oliver vacuum drum filter with a soundly engineered, automatically controlled roll and tracking system.

In most cases, dry cake falls automatically off the bowed discharge roll. A doctor blade, wire scraper or sluice nozzles may be used where required. An external wash system using high velocity jet sprays minimizes blinding and permits use of a closer weave cloth for greater filtrate clarity. A wide variety of cloth may be used, depending on slurry characteristics.

For full information, write for Bulletin #7203 to Dorr-Oliver Incorporated, Stamford, Connecticut.

range of filtration problems

Belt-Type Filter



DORR-OLIVER

WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT

Allied now uses the conventional phenol process at its Hopewell, Va., plant.

Like Allied, Toyo now employs the phenol route at its 60-ton/day Nagoya facility. But the firm is now in the midst of revamping half of the plant to make 30 tons/day by the new photochemical technique.

This is all that's known about the Toyo process: cyclohexane, into which nitrosyl chloride has been diffused, is treated with light energy in the 3,650-6,000 Angstrom range. Product is cyclohexanone-oxime, with some unconverted cyclohexane that is recycled. The oxime is then converted to caprolactam via conventional techniques.

Toyo says that it is considering licensing the process.

Continental Oil is teaming with Germany's Deutsche Erdoel to build a 50-million-lb./yr., $15-million fatty alcohols plant employing the Ziegler process. Erdoel will supply ethylene from its Heide refinery while Conoco will furnish process know-how developed while building a similar plant at Lake Charles, La.

Canada's biggest sulfur plant will aggravate existing market pains

Plans for the world's second-largest sour-gas sulfur plant have reached the contract stage. To be built for Shell Oil of Canada by Canadian Bechtel, the 550,000-ton/yr. installation yields only to the 1-million-lb.-plus plant at Lacq, France.

But the question of how to market all this Canadian sulfur is big, too. With its present capacity of 700,000 tons/yr., Canada already has a 300,000-ton stockpile.

In addition to the Shell plant, due for start-up early in 1962 in the Pincher Creek area of Alberta, other installations planned or under construction (all in Alberta) are: Pan American Petroleum, 650 tons/day; two for Jefferson Lake Petrochemicals, 700 and 300 tons/day; Home Oil, 20 tons/day; Western Leaseholds, 75 tons/day.

It costs at least $12/ton to move Alberta sulfur to the nearest waterways. And so far, Canadian sulfur has not been able to compete with Gulf Coast and Mexican products except in northern California and the Pacific Northwest.

Yet some U. S. Frasch-sulfur producers are pessimistic. One spokesman queried by *CE* seemed ready to concede that Frasch product would only be able to hang on to its current consumption tonnage, while Canadian sulfur's share grows with the growing world market.

National Society of Professional Engineers is actively campaigning in support of engineering sounding boards (Chem. Eng., ***Feb. 6, p. 112***) ***as a means of promoting the goals of the profession. It is urging support of legislation (H.R. 412) that would add language to the Taft-Hartley Act to exempt these boards from labor-law restrictions.***

Will thermoelectric refrigerators seriously cut fluorocarbon sales?

Manufacturers of fluorocarbon refrigerants—whose products are used in over 90% of all new refrigerators—are starting to wonder how great a threat is posed by thermoelectric cooling devices. Prompting this concern is next month's debut of the first commercial thermoelectric freezers, made by Borg-Warner's Norge Div.

Refrigeration now accounts for about half of all fluorocarbons sold. But marketers surveyed by *CE* say that thermoelectric devices probably won't pose a serious threat for five years—barring an immediate breakthrough.

To score such a breakthrough, manufacturers need a thermoelectric material with thermal efficiency significantly greater than the bismuth telluride now used. A step in that direction could be Hughes Aircraft's announcement that it has a material that draws only one tenth the power of conventional devices (*Chem. Eng.*, Mar. 20, p. 98).

Thermoelectric cooling is now only practical in capacities up to 300 Btu./hr., which limits size of the unit drastically. Norge's commercial unit is only 0.5 cu. ft., will be used in hotel rooms to freeze ice cubes. Manufacturers of thermoelectric materials say it is possible that the new devices may not crack the household refrigerator (average capacity: 12 cu. ft.) market before 1970.

But even if the breakthrough comes before

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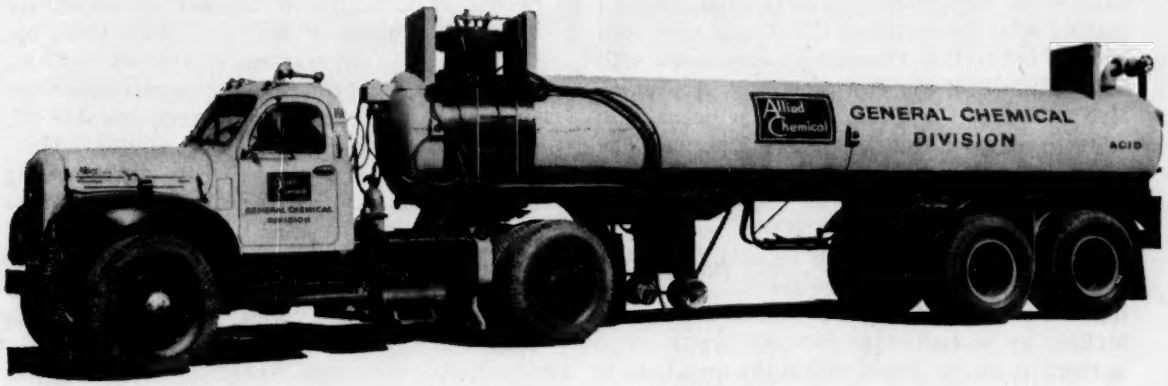

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then, fluorocarbon makers believe they have a compensating development at hand. Urethane foams blown with fluorocarbons, which have already made deep inroads into glass fibers' refrigerator insulation market, are expected to more than make up any losses to thermoelectrics.

High-capacity German coke oven reaps dividends from flue redesign

Coke ovens with 50-60% greater capacity than that of most conventional U.S. ovens may soon be built in the U.S. Through an agreement with Firma Carl Still of West Germany, Arthur G. McKee & Co., Cleveland, has been licensed to build the bigger ovens in North America. The venture marks McKee's entry into the coke oven field.

Higher capacity of the Still oven comes from its height of 20 ft., which puts it far above most U.S. ovens, which are normally 10-14 ft. high. The increased height is made possible, says McKee, by a multistage heating system with burners at several levels within the oven flues to insure even heating over the full wall height.

Most U.S. ovens have burners placed at one or two levels near the oven bottom. Using this system, oven height is limited, because for those taller than the ones now commonly in use, an excessive temperature would be needed in the bottom of the flue to maintain the top of the oven at the required temperature.

The Still ovens, using conventional coke-handling and byproduct recovery equipment, gain their advantage from the higher output per unit. When tested, American coking coals yielded coke quite similar to that made in the U.S. If anything, coke quality tends to be better because the taller oven results in increased bulk density of the charge during coking, which usually enhances coke quality.

Japanese para-xylene process touts low-temperature crystallization

Japan, frequently a recipient of foreign technical know-how, wants to export a *p*-xylene process. to the U. S. Relying on the results of a 20-ton/day plant as a basis for proposals, Choji Kato, managing director of Maruzen Oil, Tokyo, recently toured the U. S. (and West Germany) to see where he could arouse interest in the process

Maruzen's route to *p*-xylene involves heating mixed xylenes to 950 F. at atmospheric pressure with silica-alumina as a catalyst, then dropping the temperature to —94 F. for separation by crystallization. From feed containing 20% *p*-xylene, recovery is about 90%. Cost of production is claimed to be at least 10% lower than that of *p*-xylene produced by existing processes.

Low-temperature fractional crystallization is a common route to *p*-xylene made by U. S. manufacturers. Cosden Petroleum's plant at Big Spring, Tex., using a process developed by Phillips Petroleum (*Chem. Eng.*, Dec. 1955, pp. 128-132), chills out *p*-xylene crystals at —107 F., purifies them in a continuous column under pressure. One of the largest producers, Humble Oil, uses indirect refrigeration in its Baytown. Tex., plant to cool crystals to "less than —70 F." Other producers are said to use —70 F. (temperature of dry ice) for the crystallization step.

Most *p*-xylene is used as raw material for terephthalic acid, which in turn is used to make polyester fibers and films such as Du Pont's Dacron and Mylar.

Industry sources report that Du Pont has developed a new and cheaper route to terephthalic acid, starting with toluene. If so, the Maruzen process may find tough sledding here, particularly if *p*-xylene prices slip as observers predict, and if Humble goes through with its plans to expand its Baytown capacity from 65 to 105 million lb./yr. by early 1962.

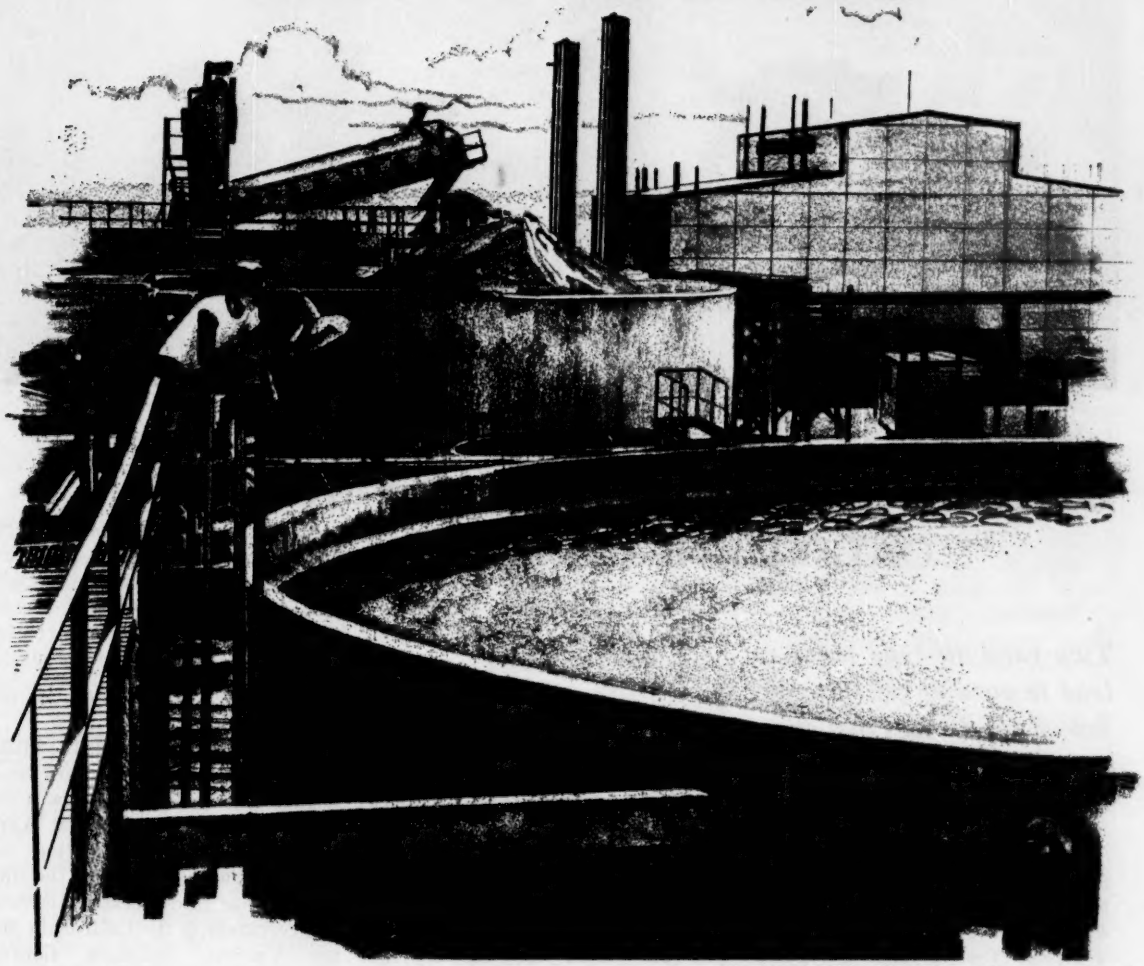
Research and development briefs

Electrowinning of copper and zinc together is being undertaken by the department of chemical engineering at Oregon State College. Goal: to develop a way to utilize the copper and zinc ores found in some of the state's inactive mines. Copper and zinc levels are not high enough to make it worthwhile to go after the two metals separately. But an electrolytic process for producing the two together (as a type of brass), or for separating them, could make the mining profitable.

Protection of rubber from ozone attack may get help from antiozonant research now underway at Bell Telephone Laboratories. Increased understanding of the inhibiting mechanism will lead to better antiozonants for ozone-laden smog environment in cities.

For More Industry & Economic News . . . p. 88

GLC Anodes Are CUSTOM MADE for Stauffer Chemical Company



The Stauffer Chlor-Alkali Plant at Henderson, Nevada

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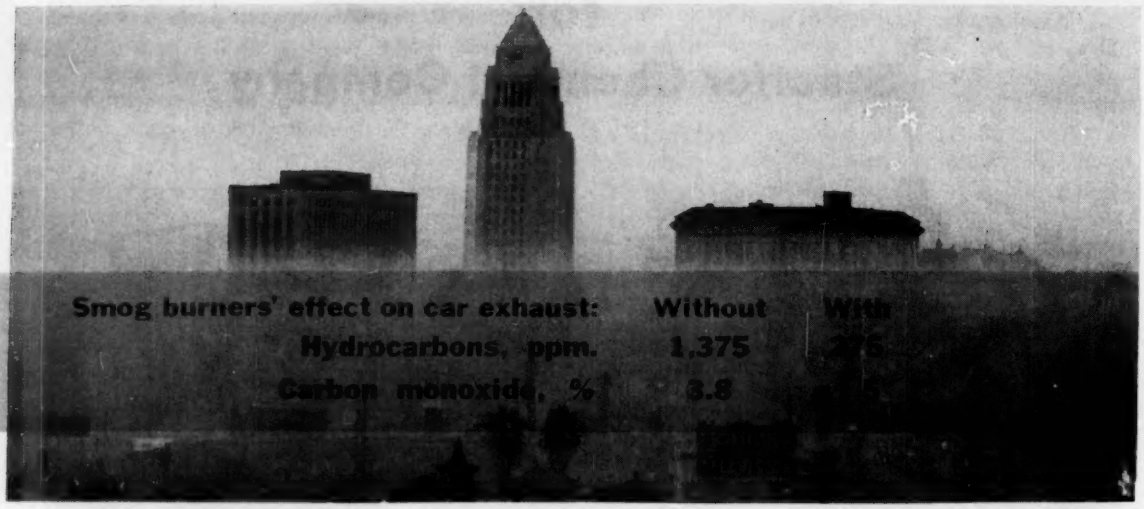


EXHAUST CONVERTERS TO SMOTHER CALIFORNIA SMOG AT SOURCE

Two catalytic-type mufflers lead in race to get state approval for devices that eliminate smog-producers in automobile exhaust fumes.

Automobile exhaust fumes, the greatest contributors to California's famous smog, will soon be squelched at the source.

Two firms—Universal Oil Products and Arvin Industries—recently filed applications with the state's pollution control board covering special mufflers designed to eliminate most of the smog-producing fumes from automobiles.

The devices, which will cost about $50 more than a regular muffler, convert objectionable hydrocarbons and other exhaust products through catalytic action. The resulting gases are expected to be free of fog-forming contaminants.

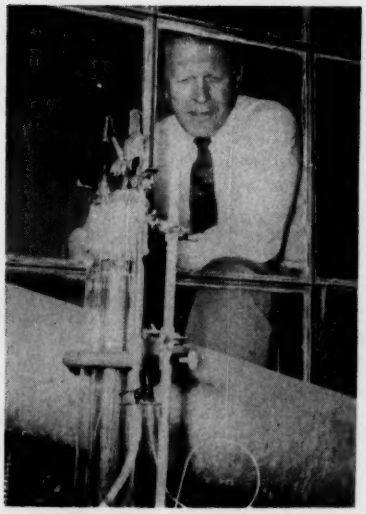
▶ **How It Forms**—The problem is most critical in the Los Angeles Basin. The city lies between three hills and the sea; frequent atmospheric inversion layers occur where a flat layer of warm air lies above a cooler ground layer. Pollutants trapped by the inversion lie static and absorb huge quantities of sunshine. Result: a photochemical reaction that produces the eye-searing vapors.

It didn't take much investigation to discover that automobile crankcase and exhaust emissions contributed most of the specific pollutants that were causing the trouble. Needed: a cheap but effective device, to be attached to auto exhausts, that consumes or converts the noxious vapors, ridding the atmosphere of their presence.

The quantity of contaminants to be removed is considerable. Recent estimates place hydrocarbon contamination due to autos at 1,500 tons/day; all the refineries in Los Angeles County put out only 90 tons. Pollution experts figure that the hydrocarbon content of the average auto exhaust has to be cut 80% from 1,375 to 275 ppm., and carbon monoxide content from 3.8 to 1.5%. (Current CO level is not critical, but extrapolated curves rate it a big troublemaker by 1970 if its emission is not arrested now.)

▶ **From Talk to Teeth**—Incentive for developing a satisfactory smog burner (afterburner) switched from talking to action last April when California legislation decreed that within a year of the time that two or more exhaust devices are certified by the California Motor Vehicle Pollution Control Board (MVPCB), all new cars registered in the state must be equipped with an approved exhaust device.

Two types of afterburners have been proposed for destroying the undesirable components of exhaust gases: (1) a direct flame device that by the addition of air and heat, completes the process of combustion started in the cylinder, and (2) a bed of catalyst that speeds the consumption of unburned hydrocarbons and carbon monoxide with air before the exhaust gas is vented. For the chemical industry, the catalytic device is the more interesting of the two.



Eyes streaming, an air pollution official suffers from a synthetic smog.

▶ **Must Solve Problems**—The manufacturer is faced with two problems—to select a catalyst, then design the unit to hold it. Any catalyst that speeds the complete oxidation of CO and hydrocarbons is a possibility. Oxides of Cr, Mo, W, Ni, Pd and Pt have demonstrated their suitability for oxidizing both CO and all three types of hydrocarbons—paraffins, olefins and aromatics.

For practical use, the catalyst selected must have certain characteristics:

• Quick warmup—On short trips, the ability of the catalyst to quickly reach maximum efficiency determines its over-all effectiveness.

• Chemical stability—An ideal catalyst is immune to poisoning from lead salts and sulfur compounds from gasoline, and from barium salts—a common lube oil additive.

• Thermal stability—During engine deceleration, hydrocarbon content of the exhaust gases reaches an extremely high level. Result: considerable heat, evolved as the excess load is oxidized, may sinter the active surface of the catalyst and destroy its activity.

• Physical stability—The continual shaking and frequent, more violent, shocks characteristic of the auto can abrade the catalyst pellets, producing channeling in the catalyst bed. If the abraded dust is toxic, no abrasion can be tolerated.

• Reproducibility — Since a relatively small amount of catalyst goes into each unit, the activity level of the batch must be fairly even.

• Low cost and long life—These are inherently desirable catalyst characteristics.

▶ **After Catalyst, the Package**—Having selected a catalyst that best meets these criteria, the manufacturer must design a system to use it. Practical car application can become more difficult than the original problem of converting the exhaust gases.

To begin with, there are more than 400 different mufflers on sale for vehicles now on the road, and upwards of 1,500 different exhaust and tailpipes. The exhaust system, least glamorous part of the car, is also usually the last to be designed, hence is tucked into the space remaining after provision is made for motor power, power accessories, passenger comfort and styling appeal.

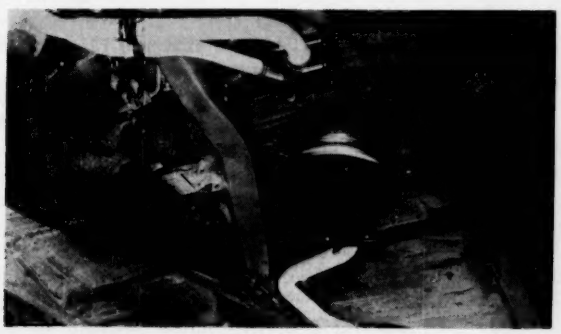
The device must be fitted within this limited space. It must simultaneously convert the exhaust gases, muffle the roar of the engine and dissipate exhaust heat without harming other components in the car.

▶ **Second Gold Rush?**—A procedure was set up for handling the anticipated horde of individuals and companies who might sense a potential second California bonanza:

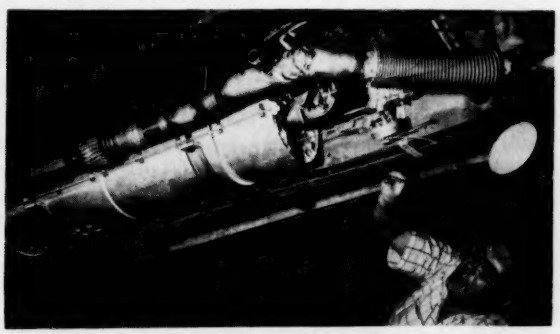
• An applicant must indicate to the MVPCB that he has developed an afterburner and wants it considered by the board. He is then furnished with the information that must be submitted when formal application is made.

• Data required in the application must indicate the type of device, how it works and how it meets the criteria established for contaminant consumption, useful life, ease of inspection, cost, etc. Application forms are then screened by the board's engineering staff to determine whether a particular device can do the job and has been sufficiently developed to warrant state confirmation road testing.

• Any manufacturer who satisfies the board that his device meets these criteria is then asked to submit 25 prototype models for road testing. Maker must specify which of five general classifications of autos his afterburner will fit, and



Typical catalytic muffler is UOP's Purzaust, mounted to replace muffler. Second hose brings in combustion air.



Direct-flame afterburner by Thompson Ramo Wooldridge, may be submitted for state approval after more tests.

indicate how it can be adapted to models in other classifications.

Donald A. Jensen, executive director of the board, says that over 140 firms and individuals have made the initial contact and presumably have an afterburner in some stage of development. He doesn't expect to get more than 40-50 complete applications; the number whose devices will be accepted for the 20,000-mi. road test will be even smaller.

▶ **Early-Bird Applicants** — Thus far, only two manufacturers have completed the formal application —Universal Oil Products Co., Des Plaines, Ill., and Arvin Industries, Columbus, Ohio. Both companies are offering mufflers that convert objectionable hydrocarbon and other exhaust products through catalytic action. The devices differ in shape and construction.

Arvin and UOP have an agreement to exchange technical information concerning antismog devices; Arvin may also use UOP's catalyst.

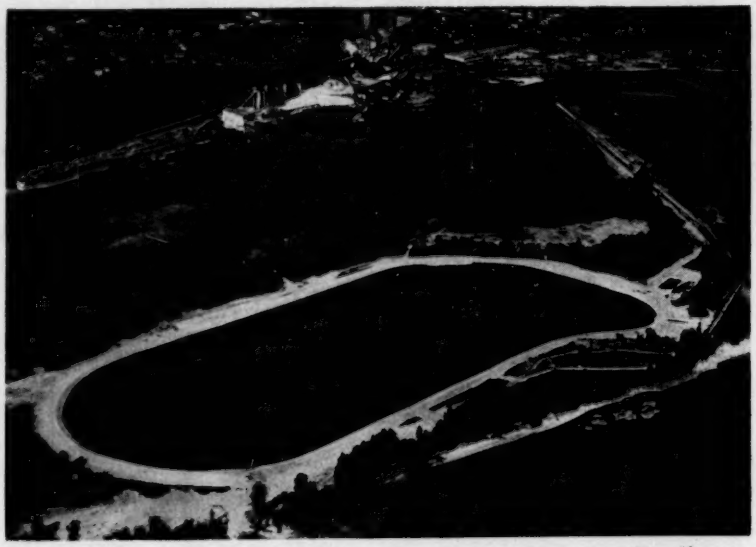
Most firms that are developing afterburners have been reluctant to disclose any details or make other than general claims for their products. However, UOP revealed the following information about its device, called Purzaust, when application was made for California certification:

The Purzaust muffler uses catalyst to reduce hydrocarbon emissions by 89% and carbon monoxide by 76%. (State standards require 80 and 60% respectively.)

Effective life is predicted to be 2 yr., based on 25,000 mi. total travel for both catalyst and case. After that period, a whole new unit would be installed. Operating temperature ranges from 400-1,250 F., depending on car's speed. The catalyst itself, while unidentified, is said to have resisted poisoning from leaded gasolines during tests, and to be nontoxic.

▶ **Cut Down Blowby**—Controlling exhaust emissions is only part of the problem. According to studies at Southwest Research Institute, 25-50% of the deleterious vapors emitted by the average auto don't come from the exhaust at all, but occur when unburned gasoline and oil vapors escape between the pistons and the rings.

These fumes, known as "blowby," have already been brought partly under control. Every new car sold in California is now equipped with a device that recirculates vapors back through the motor to insure their complete combustion. Costing only $5-10, the devices are not required by law, may be removed if the buyer requests it.—FCP



Key to system is this 46-acre lagoon for storage of spent sulfite liquors.

STOP-START DISCHARGE ENDS DISPOSAL WOES

Faced with net- and anchor-line fouling from bacteria that thrive on paper mill wastes, Crown Zellerbach initiated crash research program that came up with a simple answer—don't feed bacteria regularly.

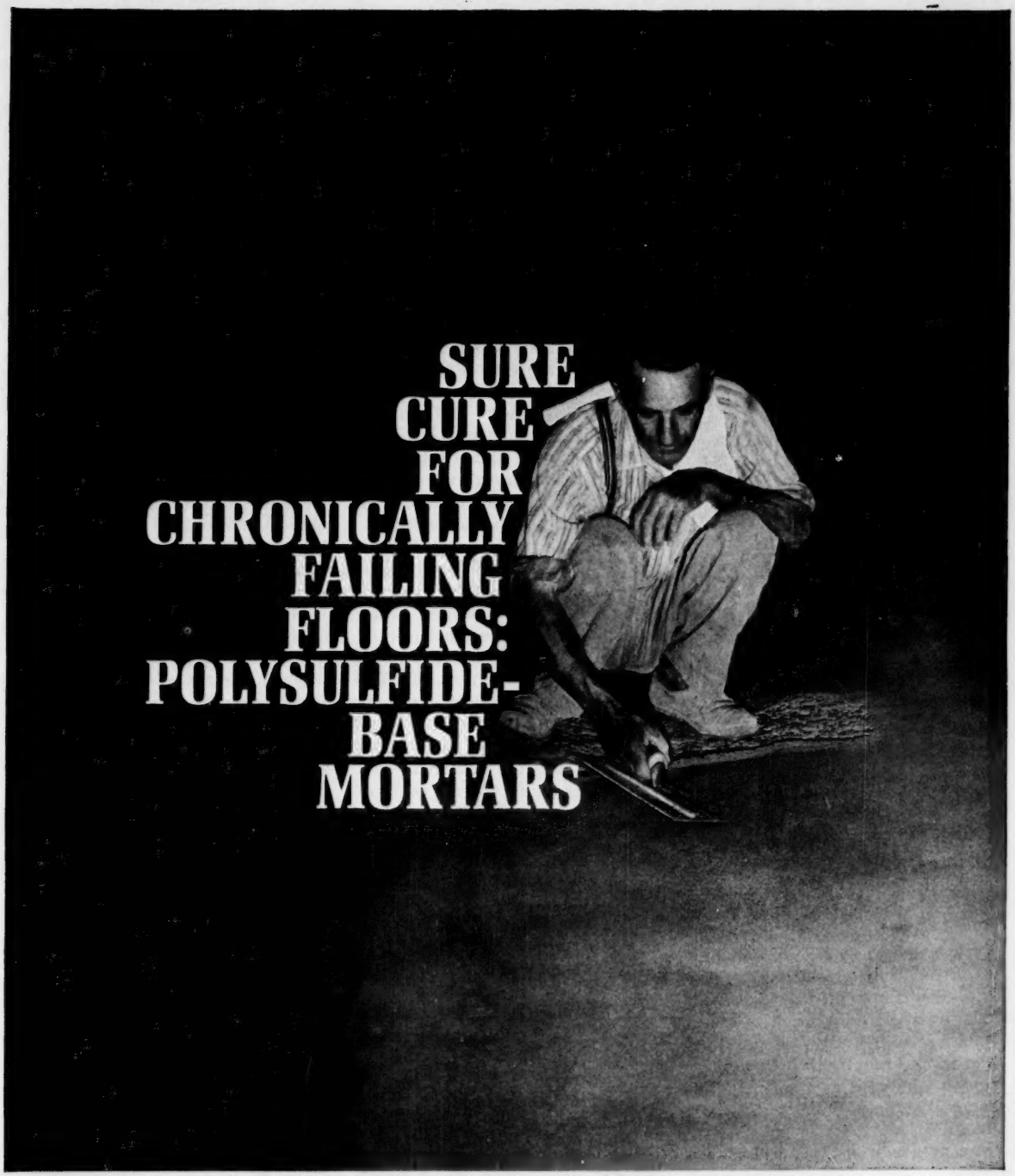
Columbia River salmon fishermen were glad to see the 1960-61 winter end. But they were overjoyed at the demise of another vexation, the excessive slime that had fouled their nets.

The reason: a $750,000 system for handling sulfite liquor at Crown Zellerbach Corp.'s, Camas, Wash., paper mill—key feature of which is the 46-acre lagoon shown above.

Developed in a crash research program carried out jointly by CZ and the Washington State Pollution Control Commission, the system will provide intermittent discharge of the dilute liquor into the Columbia River. This will starve the filamentous bacteria, *Sphaerotilus natans* that are responsible for the fouling.

▶ **Why the Slime?**—Primary sources of pollution in the lower Columbia are domestic sewage, spent sulfite liquor and various industrial wastes.

The sulfite liquor that originates at CZ's mill represents about 94 tons of wood sugars per operating day. The hexane sugar and acetic acid in this liquor provide carbohydrates necessary for growth of the *Sphaerotilus*, generally found



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How different feedings affect bacterial growth

Time in days	BACTERIA: numbers under continuous feeding	intermittent feeding
1	4	4
2	16	
3	64	
4	256	
5	1024	
6	4096	16
7	16,384	
8	65,536	
9	262,144	
10	1,048,576	
11	4,194,304	64
12	16,777,216	
13	67,108,864	
14	268,435,456	
15	1,073,741,824	
16	4,294,967,296	256
17	17,179,869,184	
18	68,719,476,736	
19	274,877,906,944	
20	1,099,511,627,776	
21	4,398,046,511,104	1024

in steams receiving this type waste.

But the sulfite liquor alone would support very little growth, for it contains practically no phosphorus and nitrogen, both of which are essential for optimum growth.

However, the domestic sewage, agricultural runoff and irrigation return waters in the river contain both of these elements. When mixed with the sulfite liquor, they cause the *Sphaerotilus* to reproduce logarithmically, resulting in the excessive slime growth found in the river below Camas.

▶ **Laboratory Studies**—Because of the many uncontrollable variations and difficulty in attaining equilibrium growth conditions in the river itself, it was decided to simulate stream conditions in the laboratory.

Preliminary experiments were conducted at Oregon State College on a pulp & paper industry-sponsored project using a continuous-flow apparatus comprising 12 glass columns 60 in. × 2½ in. Results showed that discharge of waste for 2 hr. followed by a storage period of 22 hr. was effective in reducing slime growth by more than 80%.

Following these findings, H. R. Amberg and J. F. Cormack of CZ's Central Research Div. conducted additional experiments to verify the above results. In this study, a series of 12 horizontal channels were constructed. Each channel received a continuous supply (900 ml./min.) of water and waste, from a constant-displacement multifeed pump, capable of delivering 24 solutions simultaneously.

Incoming water was steam-heated and maintained at a constant temperature by a thermostatically controlled immersion heater. Velocity was kept uniform by power-driven paddle wheels placed in each channel. Quantitative determinations of growth were made, and microscopic examinations of the organisms were conducted.

Very little slime growth was noted in channels receiving 10 ppm. spent sulfite solids and phosphorus-deficient water. However, when the sulfite solids were supplemented with 1 ppm. of phosphate, slime growth more than doubled. Domestic sewage in small amounts produced the same result.

It was conclusively shown that optimum growth occurred only when waste liquor was fed continuously at constant concentrations, and that interruption of the feeding schedule was effective in reducing the growth. Excellent reductions were obtained with a feeding schedule of 2 hr. followed by a storage period of 22 hr.

But this procedure was subject to the following objections:

- It would result in a 12-fold increase in concentration of waste.
- The interval between discharges would decrease downstream, and ultimate merging of discharges would likely occur.

To overcome these objections, both discharge interval and storage periods were increased until an effective arrangement—24-hr. discharge period followed by 4 - 5-day storage—was worked out. Subsequent laboratory work showed the effectiveness of this modified program, and slime reduction in excess of 90% was attained.

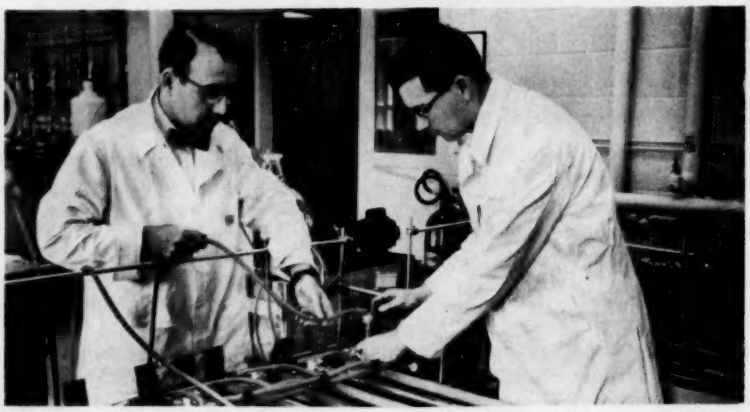
▶ **Pilot-Plant Studies**—To simulate natural conditions, a pilot-plant study was set up on the Columbia River, using five log rafts secured about 200 ft. from the shore where stream velocity was about 0.5 fps. Liquor was fed to the rafts through diffusers, and the slime growth was estimated by observation and measurement on ceramic tile surfaces.

Log surfaces were exposed to the following conditions:

1. Control, no spent liquor.
2. Intermittent feeding of liquor.
3. Intermittent feeding started after slime growth was under way.
4. Continuous feeding of liquor.
5. Continuous feeding at extremely low concentrations.

These field trials showed that slime growth was reduced 80-90% when using an intermittent starvation schedule of 24-hr. discharge every 5-6 days.

▶ **Intermittent Flow the Answer**—Based on these findings, a control



Channels equipped with paddle wheels that move liquid similar to stream flow confirmed previous findings on effect of spent liquor on slime growth.

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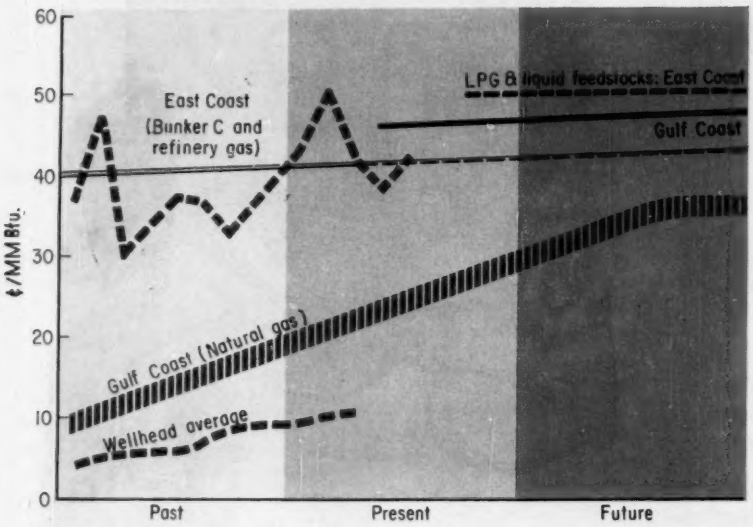
system was installed at Camas.

Key unit of the system is a 46-acre, 150-million-gal. lagoon on an island in the Columbia River. It is composed of earthern dikes with a clay core. Dilute liquors are discharged directly from the mill with a pH of 4-5, and B.O.D. of 200 ppm.

After dilution and settling in the lagoon, the leftovers are released through a 54-in. deep-water outfall line that extends about 1,200 ft. into the river.

Mill wastes are stored for 5 days, then discharged into the river for 24 hr. Usual discharge is about 90 million gal. To determine the effectiveness of this system, stream checks are constantly made.

Flow in the Columbia River is swift, so it is doubtful whether merging of the intermittent discharges will ever occur.—MDR



IS GULF COAST'S GRIP LOOSENING ON PETROCHEMICAL INDUSTRY?

Rising costs of area's raw materials and distance from major markets seen favoring a gradual switch to the East Coast. The big question: how fast?

Three astute commentators—H. K. Nieuwenhuis, Chemical Projects Assoc.; C. M. Blair, Union Carbide Plastics; K. J. Nelson, Enjay Chemical—have injected a trace of frost into an otherwise sunny forecast for the Gulf Coast's petrochemical industry with analyses presented recently in New Orleans.*

In brief, the Gulf Coast has basked in an almost unlimited supply of economically competitive raw materials for the basic petrochemical building blocks—ethylene, propylene, acetylene, toluene, xylene and ammonia. And raw-material considerations have, in many cases, overridden objections such as limited consuming population, and distance to most of the large U. S. consuming centers.

But certain trends are forming that portend a weakening of the area's raw-material dominance and a growing emphasis on its deficiencies in regard to marketing. The cost of natural gas is rising. Gulf Coast plants are also turning increasingly to the use of more valuable hydrocarbon feedstocks such as LPG and liquids. On the East Coast, large untapped quantities of refinery gas and other materials are still available at essentially Btu. value.

Nevertheless, the Gulf's current claim to the petrochemical crown is unquestionable. Any decline is sure to be slow in making much of a dent in such a mammoth and soundly based domain.

Various industry experts have estimated that petrochemicals should reach 56 billion lb. in 1960, which will be 30% of total chemical production. By 1965, these values are expected to grow to 85 billion and 40%, respectively.

► **Entrenched in Raw Materials**—Presently, about three quarters of U. S. capacity for producing petrochemicals is located along the Gulf Coast—and approximately the same proportion of all claimed petroleum reserves in the nation lie within easy pipeline reach of it.

Through the years, the Gulf Coast has been getting a larger and larger share of the petrochemical investment in this country:

Petrochemical investment
(Billion dollars)

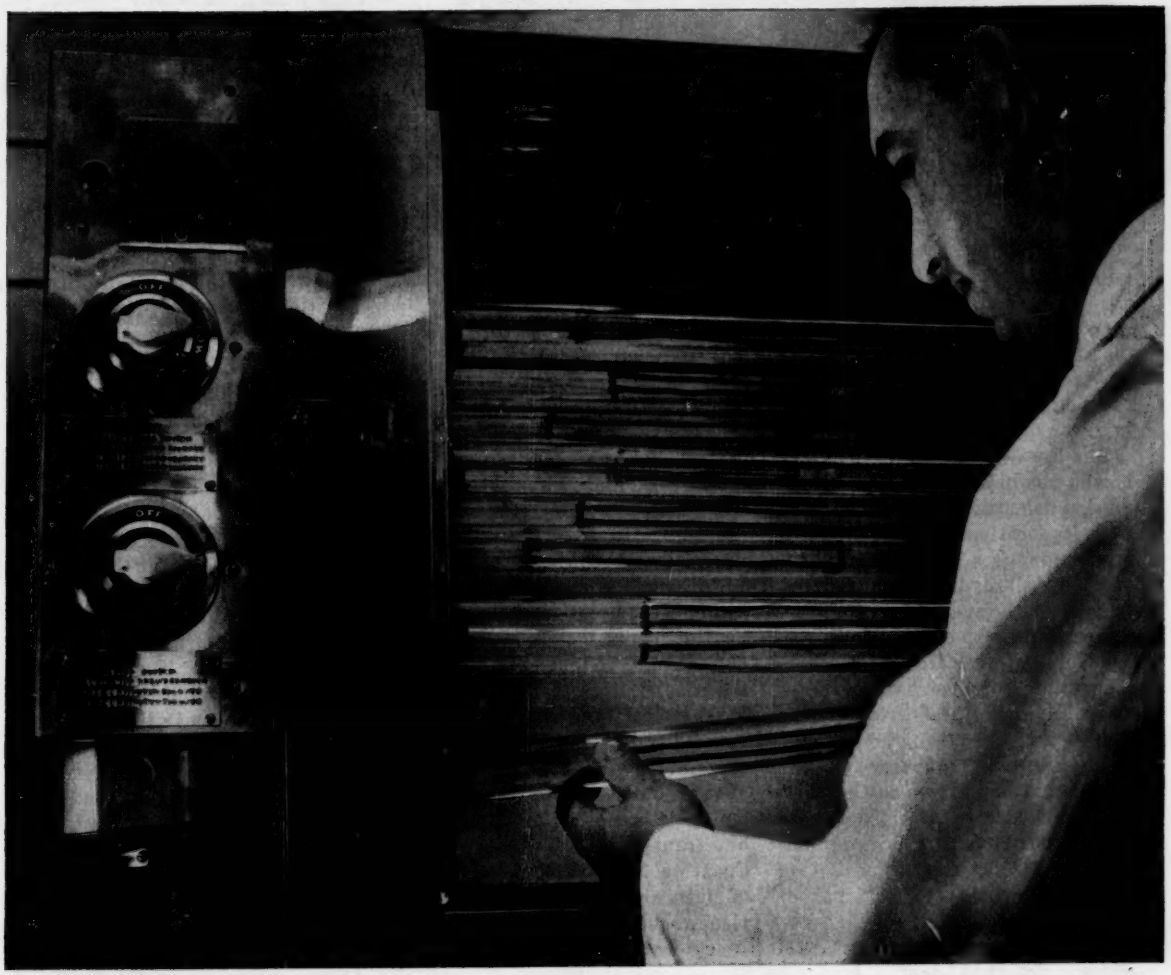
	U.S.	Gulf Coast	Gulf Coast as % of U.S.
1950	2.0	0.9	45
1959	6.7	>4.0	>60

The East Coast has a refining capacity about half as large and a chemical-and-allied-industries volume four times as large as the Gulf Coast. By contrast, petrochemical output is only about one fifth that of the Gulf's on a tonnage basis and one seventh dollarwise. The disparity is particularly pronounced for organic petrochemicals, in which field the Gulf outdistances the East by a factor of more than 10 to 1, both in volume and dollars.

In his paper, Herman K. Nieu-

*At the American Institute of Chemical Engineers' recent New Orleans symposium: "East Coast-Gulf Coast, Refinery Growth and the Petrochemical Industry," by Herman K. Nieuwenhuis, president, Chemical Projects Assoc.; "Plastics and Fibers on the Gulf Coast," by C. M. Blair, vice president, Union Carbide Plastics Co.; "Domestic Markets and the Gulf Coast," by Karl J. Nelson, vice president, Enjay Chemical Co.

WHAT'S NEWS IN ENJAY TECHNICAL SERVICE



Enjay helps reduce cost of 90°C vinyl wire insulation...

An important part of Enjay Technical Service is developing useful new products that reduce costs, yet maintain performance. Ditridecyl phthalate for use in plasticizing vinyl wire insulation is a good example of this research activity. By tests, such as the oven aging shown above, Enjay was able to prove that DTDP, made from Enjay tridecyl alcohol, performs as an efficient, non-volatile plasticizer for 90°C wire — yet reduces plasticizer cost.

Test results, at right, show that the insulation exceeds the U.L. Specifications.

Enjay research facilities and technical skills are available to customers in the vinyl wire, film and sheeting industries.

If you would like to receive a free copy of our new Technical Bulletin No. 20 on Enjay oxo alcohol for plasticizers, write to 15 West 51st Street, New York 19, N. Y.

TEST RESULTS: 7 DAYS @ 121°C

	U. L. Specification Minimum	DTDP Plasticizer
Elongation	65% retention	100% retention
Tensile Strength	65% retention	101% retention
Dielectric Strength	50% retention	127% retention
Insulation Resistance*	.01 megohm based on 1000 ft.	0.36 megohm based on 1000 ft.

* 1 day and 7 days @ 113°C.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

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ENJAY
PETROCHEMICALS

Production of petrochemicals in two areas

	East Coast				Gulf Coast			
	Tonnage		Value		Tonnage		Value	
	1950	1960	1950	1960	1950	1960	1950	1960
Total.....	2.9	7.9	3.0	7.5	38	43	43	52
Organic..	3.5	5.1	3.7	4.9	53	59	53	62
Inorganic.	1.6	13.6	0 6	11.1	8.5	16.0	8.8	17

Source: H. K. Nieuwenhuis, Chemical Projects Assn.

wenhuis, president, Chemical Projects Assoc., discusses the regional patterns of hydrocarbon values that have been important in shaping the industry, and suggests that the picture is gradually changing in favor of the East Coast.

The East Coast refining industry is, and has historically been, highly market-oriented. But hand in hand with its location in vast centers of population goes a dependency for virtually all hydrocarbon requirements on far-away producing centers. In sharp contrast, extraneous oil—whether imported from other states or overseas sources—plays an insignificant role on the Gulf Coast.

The refining industry on the East Coast has grown in the postwar period at about the same rate as that on the Gulf Coast. Its 1.5-million-bbl./day crude distillation capacity is roughly half that of the Gulf Coast.

On the Gulf, natural gas provides an abundant, low-cost source of energy and raw material, especially ethane. It sets the value of the basic Btu. in that area and indirectly also of refinery gas. By comparison, all other hydrocarbons, such as LPG and the liquids, are much more costly. Compared with a natural gas price of about 20¢/M cu. ft. or 20¢/MM Btu. for instance, LPG sells for about 4¢/gal., or 47.7¢/MM Btu. and Bunker C at $2.30/bbl. or 36-37¢/MM Btu.

The value of the basic Btu. in the East Coast refiner's economy is related to the price of Bunker C, currently about $2.60/bbl. or 41¢/MM Btu. in the New York area. This is the approximate price level at which Bunker C is at a par with coal as an underboiler fuel. Natural gas piped in from the South must also meet this price if it wishes to find outlets in its marginal markets, i.e., for underboiler use in large power plants. There also exists, of course, a considerable premium market for natural gas in the East, principally as a domestic and industrial fuel. In this use, the competitive ceiling is set by the cost of manufactured gas.

▶**Shifting Hydrocarbon Values**—In an accompanying chart, projecting future trends in hydrocarbon values, Nieuwenhuis shows the future price of the basic Btu. on the Gulf Coast leveling off at approximately 6-7¢/Btu. below that on the East Coast. This is about equivalent to the cost at which a barrel of Bunker C can be transported from the Gulf Coast to New York. If the price of natural gas on the Gulf should rise above this parity, it would become attractive for Gulf Coast petrochemical plants to switch from gas to oil. This differential then will tend to set a ceiling on the level to which gas prices on the Gulf Coast may rise.

At present, the value of hydrocarbons on the East Coast, whether as raw material or fuel, is invariably higher than on the Gulf Coast. Assuming a differential in the cost of ethylene of 1¢/lb., and in energy of 20¢/MM Btu., the Gulf Coast manufacturer could have an advantage of as much as 1.4¢ - 1.9¢/lb. in the case of high- and low-pressure polyethylene, respectively, of better than 1.2¢/lb. for glycol and of 1¢/lb. for styrene. If the ethylene cost differential should disappear and that of energy drop to the 6 - 7¢/MM Btu. level suggested earlier, the Gulf Coast's advantage would be sharply reduced and would, in many cases, be easily overshadowed by freight and other considerations.

If liquid feedstocks such as light gasoline, a problem child of the European refiner, should be permitted to enter the U. S. for use as a chemical feedstock under a special blanket import license, it is quite likely that ethylene and propylene could be made as cheaply on the East Coast as on the Gulf Coast, if not cheaper. There are indications that other nations are well aware of the advantages that could be gained from the chemical use of imported light gasoline or other low-cost liquids.

Also, byproduct credits are generally higher on the East Coast. Ethylene, for instance, can probably be made on the East Coast by the steamcracking of naphtha at a cost comparable to that for which it could be made on the Gulf Coast from the same material, notwithstanding the higher value of naphtha in the East. And, reiterates Nieuwenhuis, refinery gas is still abundantly available on the East Coast as a source of ethylene, whereas on the Gulf Coast several plants are already resorting to more costly hydrocarbons such as LPG or light gasoline.

In his paper on plastics and fibers on the Gulf Coast, C. M. Blair of Union Carbide Plastics points out that the chemical industry has scarcely tapped the hydrocarbon sources in petroleum and natural gas. To date, these have been low-cost sources because fuel has been relatively inexpensive and most petrochemical raw materials have had alternate use only as fuel. It has been estimated that about 50% of the petrochemical raw materials are byproducts of refining operations, and information concerning their price trends is not available.

Another 25% of the hydrocarbon raw-material requirements for petrochemicals are supplied from natural gas. As a raw material for chemical, textile and rubber products, natural gas has be-

Most finished products from petrochemicals are now made near markets

Basics			Intermediates			Finished Products		
Product	Gulf Coast Capacity, % of U.S.	Gulf Coast Consumption, % of U.S.	Product	Gulf Coast Capacity, % of U.S.	Gulf Coast Consumption, % of U.S.	Product	Gulf Coast Capacity, % of U.S.	Gulf Coast Consumption, % of U.S.
Benzene	55	27	Styrene	57	36	Polystyrene	25	2
			Synthetic phenol	4	6			
Butadiene	79	58	Methanol	58	12	SBR Rubber	58	2
			Formaldehyde	10	9			
Ethylene	67	67	Ethyl alcohol	52	24	Rayon	0	0
			Acetic acid	22	29	Polyvinyl chloride	22	2
			Ethylene dichloride	92	60	Polyethylene	72	2
			Vinyl chloride	68	22			
			Ethylene oxide	60	60			

Source: Karl J. Nelson, Enjay Chemical Co.

come increasingly popular, increasing over fivefold in tonnage for chemical and allied products, and over sevenfold for textile products during the '50s.

▶ **Basic Prices Rising**—However, Blair notes that during this same period the average wellhead prices for natural gas have risen greatly. It must be remembered that these prices were at their lowest when the petrochemical industry was in its infancy and engaged in choosing the most economical raw material. Between 1950 and 1958, the national average increase in wellhead prices was 83%.

For Texas, the increase was 113%; Louisiana, 143%; Florida, 162%.

Liquefied petroleum gas, as a raw material for chemical and rubber products, has also benefited from a growing market, accounts for the remaining 25% of the petrochemicals raw material. The use of LPG for chemicals was almost fourfold greater in 1959 than it was in 1950. During this same period, rubber products consumed about twice as much. But here, too, we see prices of LPG rising 38% from 1950 to 1959.

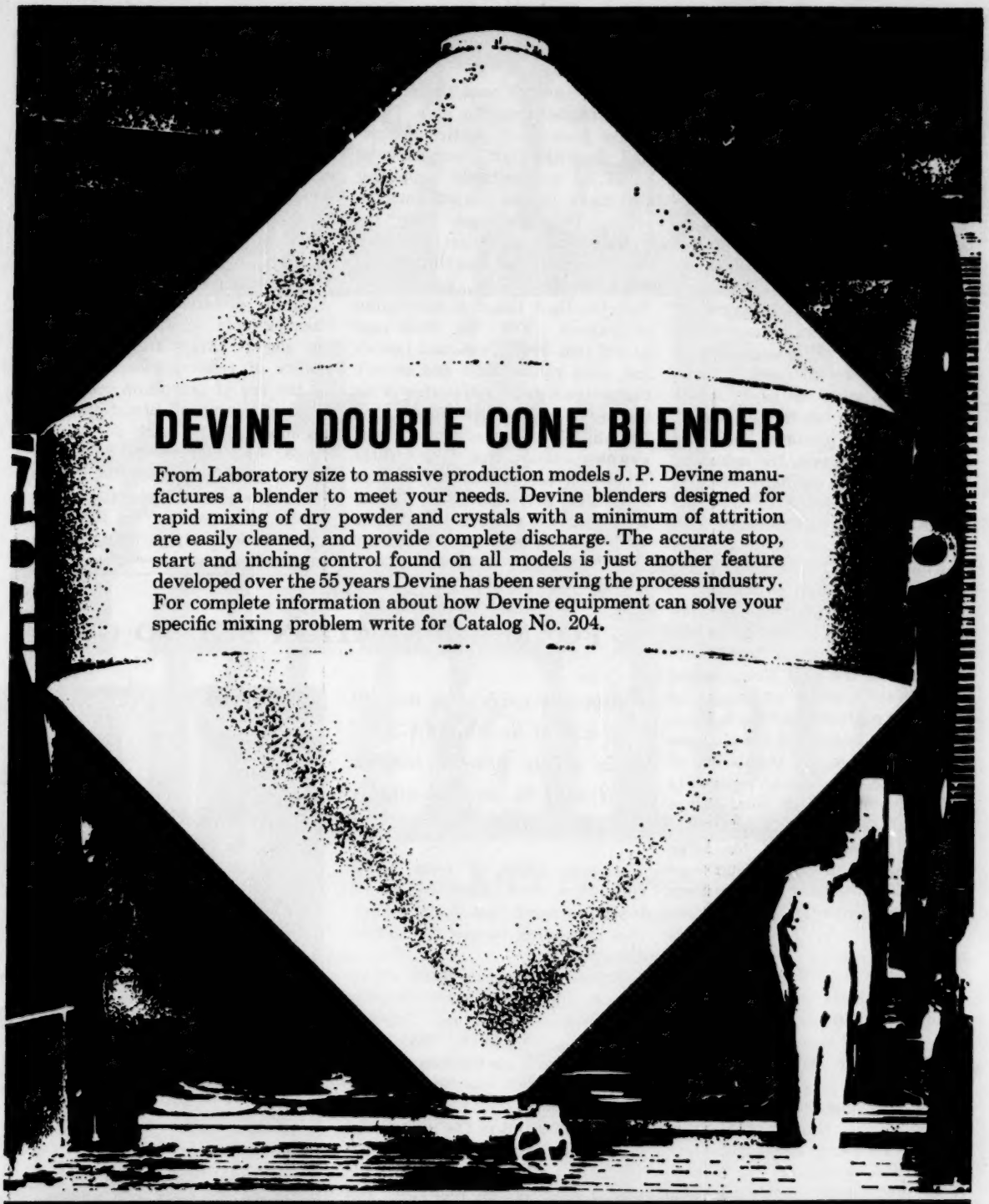
Today, in some areas of petrochemical production, petroleum-derived raw materials can no longer be classed as byproducts. In such instances, we see—instead of an industry founded to exploit otherwise-low-value surplus materials—an industry having to compete for specific materials. This development, by its very nature, means that some of the petroleum-derived building blocks for the chemical industry are more expensive. Because all raw materials increase in cost, and more valuable fuel uses are found for the typical petrochemical raw materials, the physical presence of many such hydrocarbons in natural gas and refinery streams does not necessarily indicate an almost unlimited future economical supply.

Karl J. Nelson, vice president of Enjay Chemical Co., predicts that the Gulf Coast will continue to receive a large share of the new construction for petrochemical raw materials and intermediates, but that it will probably decline as costs of construction, fuel and labor approach those of other parts of the country, which have by virtue of their location a transportation advantage over the Gulf in supplying the ultimate user. Of the areas Nelson investigated, New Jersey may be the first to gain any Gulf losses.

▶ **Far-Away Markets Beckon**—In the first of a series of tables (above), Nelson shows that the Gulf Coast both manufactures and consumes a very high percentage of such basic petrochemicals as benzene, butadiene and ethylene, which are made directly from petroleum or natural gas.

The second table presents similar data for some of the intermediates that are produced from these basic chemicals. Here again, in general, Gulf Coast capacity as a percent of total U. S. capacity is quite high. For such products as styrene, methanol, vinyl chloride and ethylene oxide, Gulf Coast capacity as percent of total U. S. is in the same order of magnitude as it is for the basic chemicals from which these intermediates are derived. Other intermediates, such as synthetic phenol, formaldehyde and acetic acid, show much lower percentages. Generally, Gulf Coast consumption of these nine intermediates is lower than for the basics, signifying that there is a greater tendency for the former to be shipped out of the area for further processing.

The final table in this series compares Gulf Coast capacity and consumption for several finished products made from the intermediates. In some cases, such as SBR rubber and polyethylene, an extremely large portion of total U. S. capacity is located in the Gulf Coast. With other products, such as polystyrene, polyvinyl chloride, and especially rayon, Gulf Coast capacity is appreciably less. The actual consumption of all of these products in the area is quite small. Polystyrene, polyethylene and polyvinyl chloride are shipped out, mainly to the northeastern part of the country, for processing into finished plastic items. Similarly, rayon goes to



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the textile processing mills centered around the Carolinas and New England.

Blair notes that a large proportion of the U. S. polyethylene resin capacity is located in the Gulf Coast area. Since ethylene cannot be shipped and stored readily, the resin facilities have been located near the ethylene producing facilities. Location of the latter have been influenced by the availability of raw materials.

▶**Whither the Consumer**—In the case of the other resins, it is not as necessary to locate the polymer plant near the monomer facilities. In each specific case, the manufacturer strives to minimize his cost of product delivered to the customer. Over-all costs involve purchase of raw material, production of monomer, production of polymer, distribution of final product.

We have seen that the high concentration of petrochemical capacity for raw materials and intermediates in the Gulf Coast is not related to location of industrial consumer markets; neither is it related to the location of the ultimate consumer, since the population of Texas and Louisiana represents only 7.2% of the U. S. total. Since the Gulf Coast is a considerable distance from most of the large resin markets, transportation costs become an important consideration.

The transportation problem was less important in the earlier days of plastics because the number of resin types was limited. As the plastics business has become more competitive, it has become more and more customized. At the end of World War II, Union Carbide was producing only two basic types of polyethylene resin. By 1950, this number had grown to seven. At present, almost 200 polyethylene resins and compounds are offered. This increasing complexity plus great distances between producing plant and markets make economical transportation and warehousing considerably more difficult.

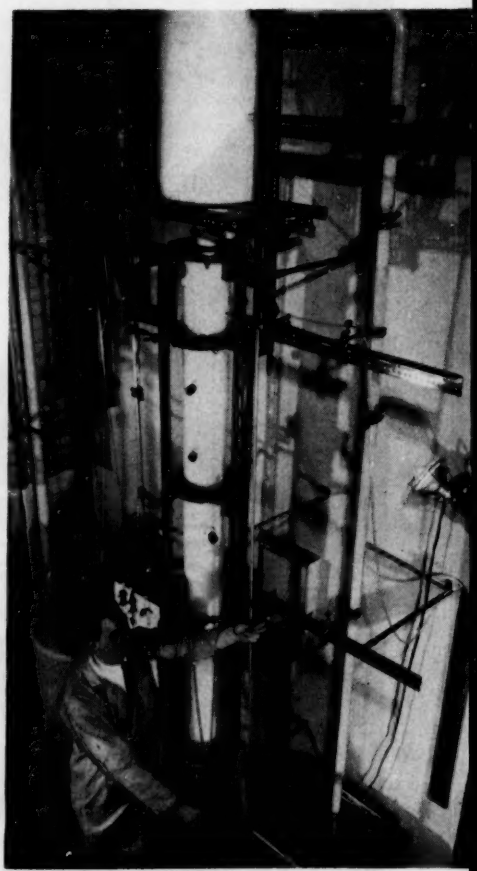
Anticipated population growth near the Gulf Coast will provide additional markets for plastic products; however, it is most unlikely that this increase will be great enough to absorb even the present resin supplies from the area. Thus, future growth of plastics production along the Gulf Coast must be based on competitively supplying customers in the distant market areas. This challenge, Blair believes, should slow but not stop plastics growth on the Gulf.

▶**Go West**—Nelson points out that the Gulf Coast is continuing to expand. For the three-year period 1958-1960, Texas and Louisiana were ranked first and second, respectively, in the Manufacturing Chemists Assn.'s annual chemical industry construction survey. Total chemical construction outlay in the three-year period was $660 million for Texas, $470 million for Louisiana. The vast majority of this construction has been for petrochemicals in the Gulf Coast area. A recent survey of petrochemical construction indicated that well over half of the newly announced projects are to be located on the Gulf.

▶**Or East**—On the other hand, Nieuwenhuis totes up at least nine major projects that are scheduled to add almost 750,000 lb./yr. to East Coast petrochemical potential. And he discerns various petrochemical aces up East-Coast refiners' sleeves. Apart from the availability of refinery gas, one could be the use of petroleum coke as a low-cost source of Btu. for petrochemical plants built across the fence. At any rate, the Easterner is becoming increasingly bullish on his petrochemical future and the tempo of expansion on the East Coast is definitely picking up.—FA

FOAM SEPARATION SET TO GO

Following successful use for removal of Sr-90 and Cs-137 from dilute atomic wastes, pilot unit is now available for plant tests.



A 6-in. pillar of foam rising through a 10-ft. glass column recently signaled that foam separation is priming to seek commercial recognition.

Following several years of research under AEC and company sponsorship, Radiation Applications, Inc., Long Island City, N. Y., has now scaled up the new unit operation to pilot size for development of commercial applications.

Announcement of the pilot facilities coincides with disclosure that the patent office has granted basic patent coverage to Radiation Applications on its foam separation technique, dubbed Foamet.

With its patent position firmly established, RAI will use its test unit to develop economic and design data on specific separation problems in cooperation with prospective industrial licensees.

▶**Chases Traces**—Companies li-

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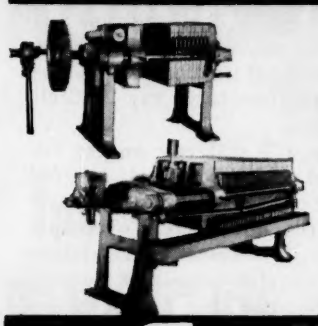

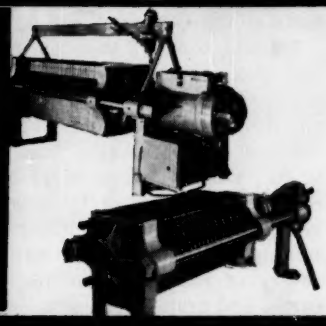

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censing the process will be able to remove solutes from very dilute solutions, either to recover the solute or to purify the solution. In a sense, this characteristic of Foamet makes it competitive with ion exchange. But Munroe F. Pofcher, RAI's president, expects Foamet also to prove beneficial working as an adjunct process to ion exchange for a number of industrial separations.

To date, working with the AEC, RAI has used Foamet to reduce the concentration of radioactive strontium-90 and cesium-137 in low-level nuclear waste from 10^{-6} to 10^{-12} molar. Among other separations the firm has investigated are: purification of solutions containing metallic impurities; recovery of radium, vanadium, rare earths and uranium; separation and purification of cobalt and nickel; removal and/or recovery of iron, beryllium and molybdenum from solutions; removal of calcium and magnesium from sea water; purification of water.

▶ **Concentrates on Bubbles**—RAI's success in performing these difficult separations rests on surface activity phenomena. If material in a solution is surface active, it will concentrate in a molecular layer at the surface of the solution.

By foaming the solution, RAI provides greatly increased surface area where the active material can concentrate. At the same time, continuous formation of the foam maintains a flow forward to a separate unit for recovery of the material concentrated on the foam surface.

In order to make a given solute surface active, RAI adds a carefully selected surface-active foaming agent to the solution that will complex specifically with the ion to be recovered. So far, the company has worked with more than 300 different foaming agents; there are hundreds more that can be investigated when the need arises.

▶ **Countercurrent Flow**—In their operation of the engineering test unit, RAI personnel add foaming agent to the feed before pumping it into the top of the 8-ft.-high countercurrent flow section of the column. (They can also introduce the foamer into the liquid pool at the bottom.)

Air or other gas enters through a sparger at the bottom of the pool, bubbles to the surface, forming foam. Continuous generation of new foam pushes the foam up the column countercurrent to the descending feed liquid. As the liquid drains over the foam bubbles, there is ample opportunity for the surface-active material to concentrate at the bubble surfaces.

At the top of the 8-ft. section, the column enlarges from 6 to 15-in. dia. After draining in this section, thereby increasing the enrichment, the foam discharges through a sidearm at the top, down a 2-in. pipe to a centrifuge that breaks the foam.

As little as one part in one hundred of the entering feed liquid discharges as enriched foamate liquid. Depleted bulk liquid is discharged from the pool at the bottom of the column.

▶ **Maximizing the Gains**—If an application calls for maximum concentration, RAI recycles some of the foamate into the column as reflux. However, this procedure also leaves ion concentration in the bulk liquid at an undesirable level for applications such as nuclear decontamination. To achieve the high order of decontamination demanded by the AEC for strontium-90 and cesium-137, RAI operated three foam columns in countercurrent series.

In the future, RAI engineers feel that they will be able to cut down the amount of time needed to prove out experimentally any difficult separation.

They will still rely on the 80-year-old Gibbs equation $\Gamma = -(a/RT) \times (d\gamma/da)$ where Γ is surface excess of the solute, a is solute activity, T is absolute temperature and γ is surface tension of the solution. But now they have a mathematical approach that will indicate the number of columns, the kind and concentration of surface-active agent prior to putting the material through the test unit. Then, processing of 50-100 gal. of feed is expected to produce the required confirming data.—CSC

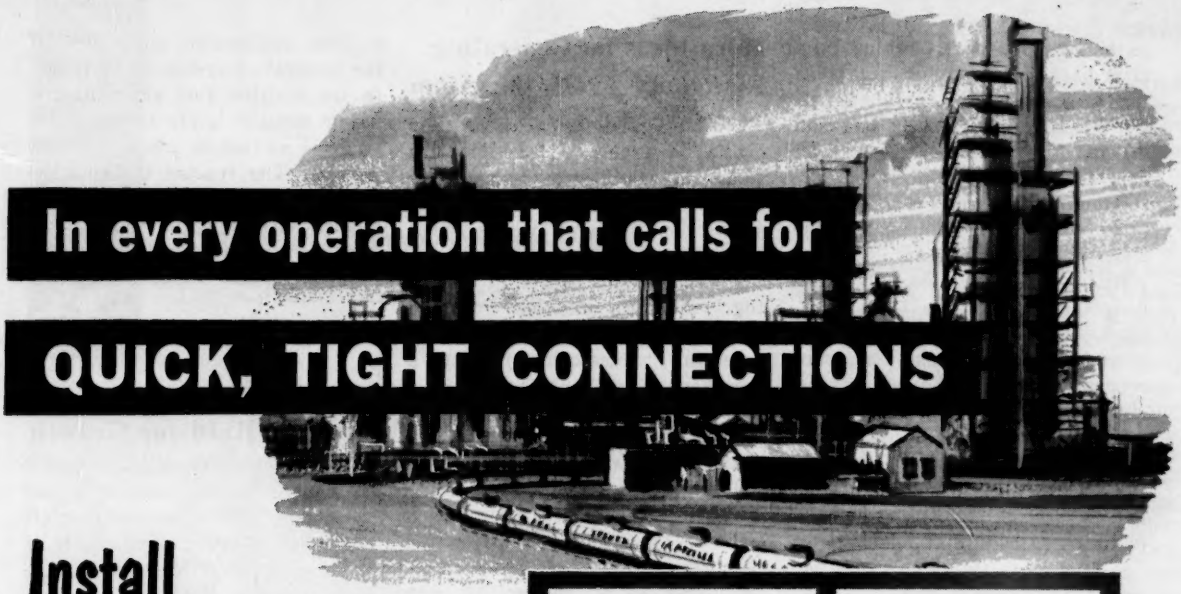
ALUMINUM BARGES ARE ON WAY

Watch for a new look in chemical carriers, as aluminum bids to replace steel in many transportation applications.

Todd Shipyards, Houston, Tex., will soon be starting construction on the first aluminum barge to be built in the U. S. To be assembled for Reynolds Metals Co., the vessel will be 98 ft. long, 35 ft. wide and will weigh more than 86 tons. It will be leased by Reynolds to Industrial Marine Service, Memphis, Tenn., for use along the Mississippi-Ohio river system, transporting perchloroethylene made by Diamond Alkali at its Deer Park, Tex., plant.

This development underscores a concerted drive being made by aluminum makers to supplant steel in transporting chemicals by water and rail. Companies base their case on three main points: (1) lighter weight of the aluminum carriers allows greater payloads that more than offset any higher initial cost; (2) maintenance costs are negligible; (3) corrosion resistance of the aluminum allows handling a wide variety of chemicals without contamination, or need for special liners. Aluminum makers also point out that by designing to take advantage of the metal's ease of fabrication, initial cost of the new carriers may be no greater than their steel counterparts.

Reynolds is also negotiating with Ingalls Shipbuilding for construction of a second aluminum barge that will be 100 ft. long and 50 ft. wide, have a tank capacity of 9,000 bbl. and carry 1,200 tons. Other producers, such as Kaiser and Alcoa, are also actively investi-



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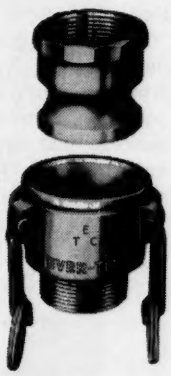

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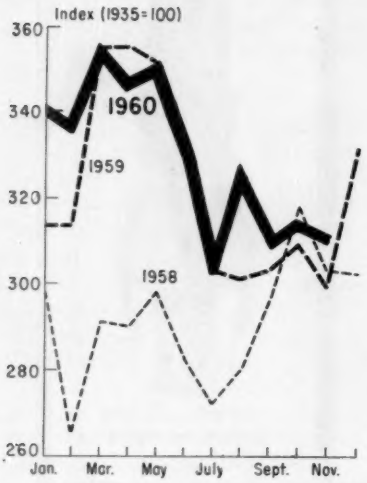
gating the potential for aluminum river barges. One factor discouraging greater activity: the current low level of river traffic has laid up many conventional barges and delayed new barge construction.

Aluminum railroad cars also are in for intensive development by the transportation industry. Kaiser Aluminum, for example, will be announcing shortly that it has developed, in conjunction with American Car & Foundry, a "new concept" in covered hopper cars, designed especially to handle chemicals and foodstuffs. And Aluminum Co. of Canada is already conducting trial runs with aluminum hopper cars for shipping lime, cement, alumina, gypsum and polyethylene.



Chemical consumption index

	Sept. (Final)	Oct. (Final)	Nov. (Est.)
Coal products	6.0	6.4	5.6
Explosives	13.4	12.6	11.5
Fertilizer	64.0	73.3	79.0
Glass	28.1	30.3	25.3
Iron & steel	11.8	12.6	11.3
Leather	4.1	4.0	3.9
Paint & varnish	40.2	33.8	30.5
Petroleum refining	31.5	31.9	30.8
Plastics	33.5	29.8	33.6
Pulp & paper	40.6	44.0	41.1
Rayon	21.3	20.7	21.7
Rubber	6.9	7.0	6.7
Textiles	9.6	9.2	9.5
Total	311.0	315.6	310.4

More Ideas on Generating Electricity From the Atom

Not all the applications for exotic atom-powered devices are found in satellites and space vehicles. Progress on two fronts shows many places where small units fill an earthbound need.

• Potentially useful in powering undersea cables, remote weather stations or any type of inaccessible telemetering facility, a new generator about the size of a breadbox can provide 5 w. of energy continuously for 10 years without recharging.

Royal Industries, Inc., Los Angeles, will build the unit, which will use thermoelectric principles to convert the energy from radioactive decay of cesium-137 into electricity. Cost will be about $20/kwh. over 10-yr. period.

• For high-energy requirements, North American Aviation's Atomics International Div. proposes a reactor-turbogenerator package that uses steam as a coolant. It differs from boiling water reactors in that, instead of the hydrogen in the water doing all the neutron moderation, about 70% of the moderation is done by hydrogen in the hydride fuel alloy. Hence, power density is six to ten times as great as that in a boiling water reactor. The reactor is being developed for surface and underseas applications under the SNAP (Systems for Nuclear Auxiliary Power) program of the AEC.

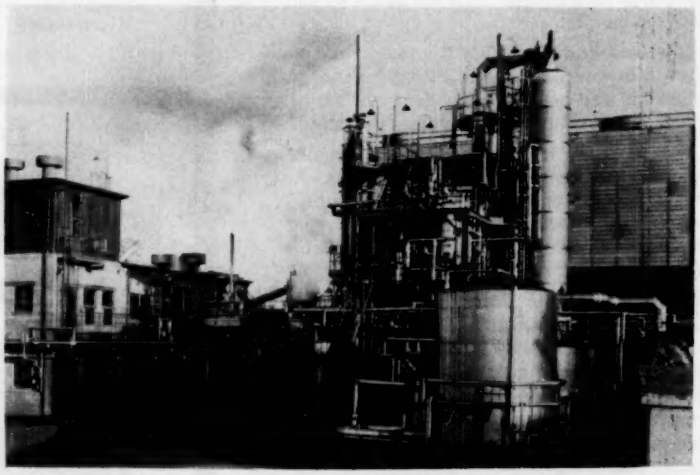
Russian Chemicals Are Fighting Hard for Growth

The Russian chemical industry is growing rapidly, and in a few years may pose a serious problem in export markets, particularly in underdeveloped countries, members of the Synthetic Organic Chemical Manufacturers Assn. were recently warned.

Alonzo P. Brown, consultant to the director of the Office of Technical Services, notes that Russian chemical production has been growing more than twice as fast as U. S. chemical output and is now second only to the U. S. industry.

Brown declares: "Although the

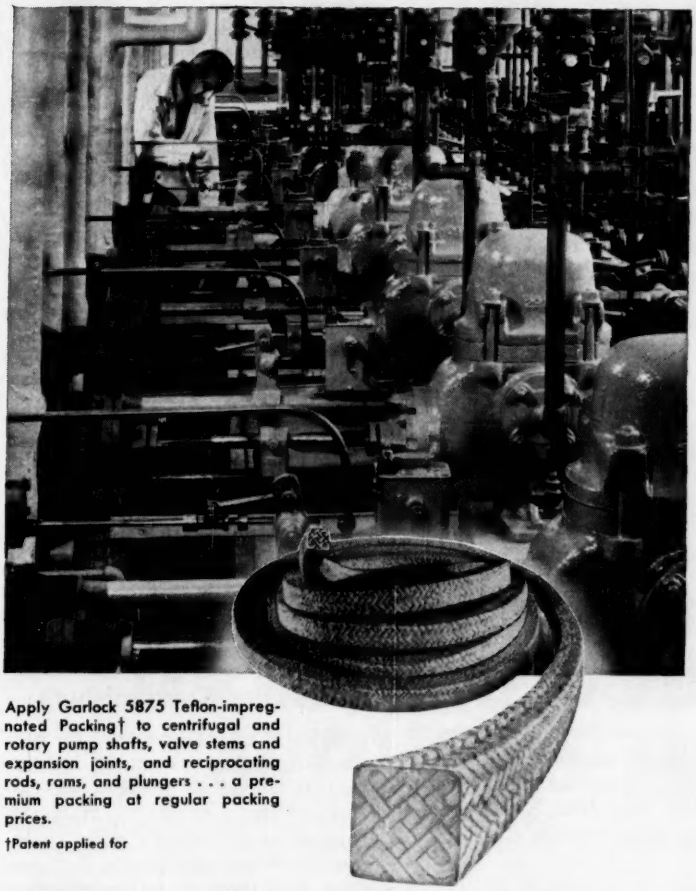
Maleic anhydride capacity gets big boost



Monsanto Canada Ltd.'s maleic anhydride plant at Lasalle, Que. (near Montreal) has gone into production just 15 months after construction plans were announced. The unit, shown above, is rated at "several million lb." annually. And Pittsburgh Chemical Co. has started production at its new 20-million-lb./yr. maleic plant at Neville Island, Pa. Both plants use the Scientific Design benzene-oxidation process.

ENGINEERED TEFLON PRODUCTS

for Chemical Processing



Apply Garlock 5875 Teflon-impregnated Packing† to centrifugal and rotary pump shafts, valve stems and expansion joints, and reciprocating rods, rams, and plungers . . . a premium packing at regular packing prices.

†Patent applied for

NEW GARLOCK TEFLON* PUMP PACKING COSTS 40% LESS!

Through an improved manufacturing technique, Garlock offers a Teflon-impregnated LATTICE BRAID† Packing at a reduction of approximately 40% over the price of similar competitive packing. Designated Garlock 5875, this packing can be purchased at prices comparable to regular packing.

Enjoy premium benefits without a premium price. Garlock 5875 offers a high Teflon content—more than 30% by actual weight—for greater protection, reduced wear. In temperatures from −90° F to +500° F, Teflon-impregnated LATTICE BRAID Packing is recommended for use against moderately destructive and corrosive mineral acids and caustics. For more destructive and corrosive applications, Garlock 5888 Teflon-treated fiber packing is recommended. Teflon, too, is as "frictionless" a material as you will find; this greatly reduces wear to the packing itself, and to any moving parts that it contacts during normal operation.

Specialized construction provides longer life, less maintenance. Garlock 5875 Packing is made from Teflon-impregnated white asbestos yarn, woven in the superior LATTICE BRAID construction. Here, each strand of treated yarn is intertwined at a 45° angle through the packing body. This completely integrates the structure for greater strength and, unlike ordinary square or round braid, eliminates individual *layers* of yarn—layers that, once worn through, destroy the usefulness of the packing. Without a layer or single outer braid to wear through, LATTICE BRAID remains unified without disintegrating far beyond the limits of other packings.

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Soviets probably won't be entering world chemical markets in any extensive way until after 1965 because of the large, unsatisfied demand at home, it is already clear that they intend to use trade as an instrument of foreign policy, especially in the underdeveloped areas."

He observes that various problems have beset development of the Russian chemical industry and there are indications that the goals in the Seven Year Plan of January 1959 will not be reached. These problems have included: production lagging behind domestic need; use of obsolete technology; lack of sufficient automation and mechanization.

The first two problems have had a common denominator: lack of sufficient Soviet experience with the catalytic synthesis of organic chemicals from petroleum and natural gas. Although a few chemicals, such as ethyl and isopropyl alcohols, and phenol, were made by petrochemical processes, the organic chemical industry of the USSR has relied mainly on coal and agricultural products as the source of its hydrocarbons.

SURVEY PEGS CHEMICAL SPENDING

MCA finds outlay for construction in 1960–61 will be second highest ever reported, despite declining net earnings.

Chemical manufacturers plan to spend $3.55 billion for 1960-61, according to the annual construction survey just released by the Manufacturing Chemists' Assn.

This is the second highest total ever reported by MCA. In a survey released at this time in 1958, total spending plans reached a record $3.84 billion. The new 1960-61 totals, however, represent a sizable increase over the slightly more than $3 billion reported in the 1959 survey.

This expansion is going on in the face of reduced net earnings for chemical manufacturers in 1960. Furthermore, average net profit of ten of the largest chemical companies, as a percentage of sales, was down from 16.3% in 1950 to 11.5% in 1959, according to N. Hathaway, vice-president of Allied Chemical. He also notes that the decline in profits coincided with a 105% rise in sales. MCA now places chemical industry sales at a $27.7-billion all-time high.

Including only privately financed projects, the 1960 survey covers a total of 348 companies, 111 of which are considered nonchemical —those whose production is primarily in fields such as steel, automobiles, paper and pulp, petroleum.

"The fact that more than 30% of the companies with new plant and expansion construction in the chemical field are outside the industry proper emphasizes the intense degree of competition in the chemical producing field," MCA president Gen. John E. Hull stated in announcing survey's results.

Survey of chemical industry investments, 1960-61

(Million dollars)

Category	Planned	Under Construction	Completed	Total
Fertilizer	99.90	78.58	46.77	225.25
General inorganic	128.90	296.57	224.09	649.56
General organic	407.60	514.67	339.53	1,261.80
Metals	13.60	26.90	21.65	62.15
Plastics & resins	25.69	358.39	181.84	565.92
Synthetic fibers	21.10	132.30	63.40	216.80
Synthetic rubber	1.00	91.75	7.58	100.33
Miscellaneous	35.42	141.61	55.28	232.31
Laboratories	39.23	96.59	101.09	236.91
Totals	772.44	1,737.36	1,041.23	3,551.03

Committee Picks Judges For Kirkpatrick Award

This year's Committee of Award has named the following members to act as judges in selecting the winner of the 15th Biennial Kirkpatrick Award for Chemical Engineering Achievement:

N. R. Amundson, U. of Minnesota
A. S. Foust, Lehigh
E. R. Gilliland, M.I.T.
D. L. Katz, U. of Mich.
J. H. Koffolt, Ohio State
J. J. McKetta, U. of Tex.
C. C. Monrad, Carnegie Tech.
M. S. Peters (Chairman), U. of Ill.
C. R. Wilke, U. of Calif.

These judges will chose the Award winner from a group of five finalists picked by the entire 99-man committee.

The award, presented in recognition of a company and its chemical engineers for the most meritorious contribution to the advance of the industry and profession during 1959-60, will be presented in New York at the Hotel Astor, on November 28.

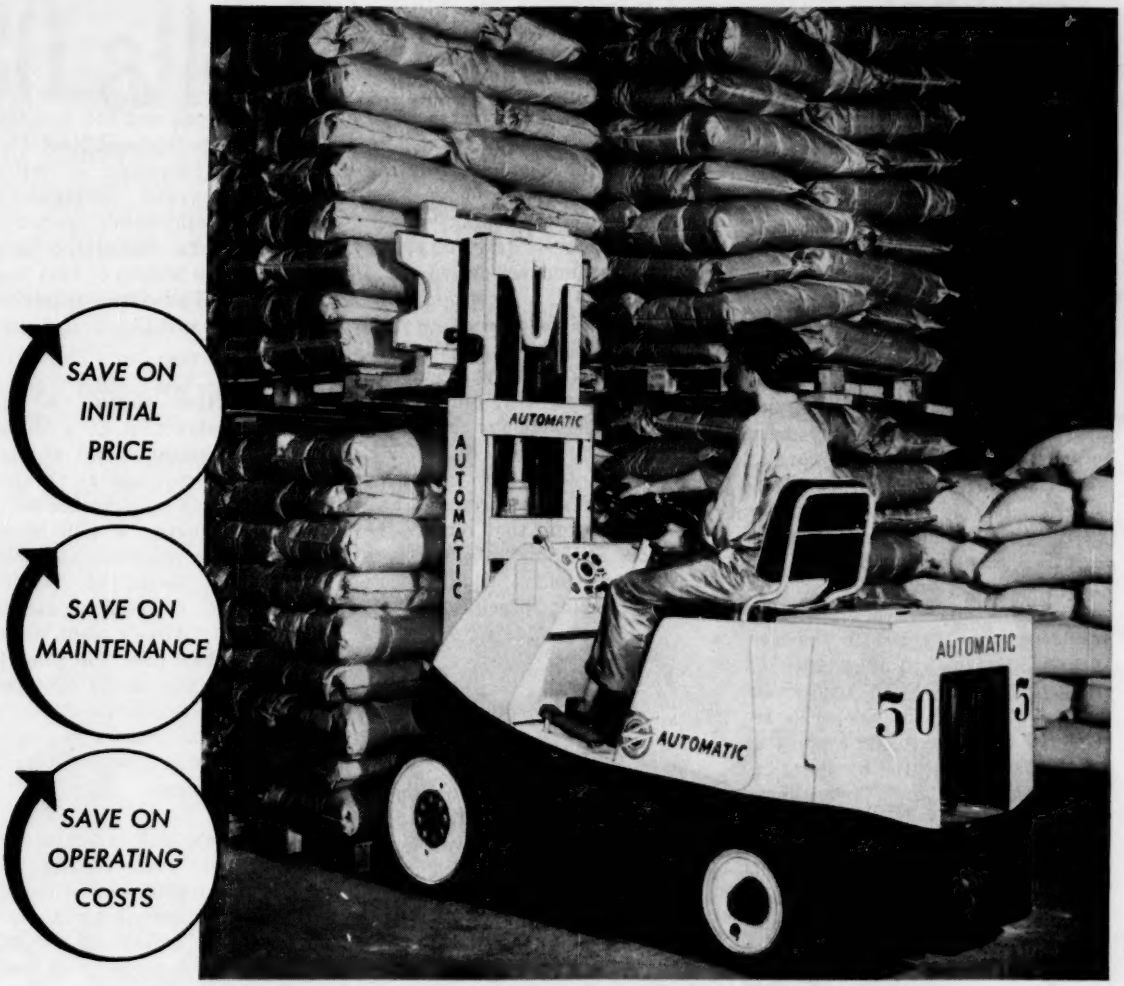
Readers should submit their nominations for the Award before April 15. (See *Chem. Eng.*, Feb. 20, p. 84, for details.)

Small Fires Hurry Testing Of Powder Extinguishers

Model fires—in size, that is—are proving to be a boon in testing various chemical powders as extinguishing agents. National Bureau of Standard's researchers use 1½-, 6- and 22.8-in.-dia. heptane fires, find them to be an effective and economic means of studying extinguishing methods.

Of the powders tested, potassium oxalate, potassium iodide, potassium bicarbonate and glass beads (listed in decreasing order of effectiveness) are the most effective. It appears that both the chemical nature and particle size of the powders influence rate at which they must be applied to squelch the fire.

Data from the small-scale tests correlate well with previous tests by others using the powders on large outdoor fires.



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With as many as 200 fewer wearing parts compared to conventional power shift units, the danger of unexpected downtime is practically eliminated. So is the cost of complex and frequent repairs. An AUTOMATIC *gas* truck means less maintenance . . . easier maintenance.

Cutting fuel bills, while at the same time increasing output, is another profit-saver. AUTOMATIC's high efficiency transmission gives higher torque while moving more tonnage per hour with less fuel.

Check initial cost. AUTOMATIC's gas lift truck is priced competitively to all other trucks of the same capacity equipped with automatic transmission.

It's a sound formula to combat the profit squeeze: save on initial cost, save on maintenance, save on operating costs.

Capacity with cushion rubber tires, 3000 to 10,000 lbs., pneumatic tires, 3000 through 8000 lbs.

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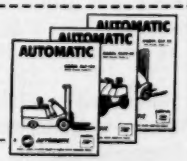

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CPI News Briefs

- Processes
- Plants
- Offices
- Companies
- International

Processes

Smelting copper with oxygen-enriched air has successfully been practiced for almost three years at the Hitachi smelter of Nippon Mining Co., Ltd. (Japan). In a paper delivered by Tamon Tsurumoto to AIME's St. Louis convention on Feb. 27, it's revealed that at Nippon Mining "pelletized copper concentrates are charged to the converter and smelted in a bath of matte through which oxygen-enriched air is blown. Copper is recovered from the converter slag as a sulfide concentrate by flotation, resulting in a high over-all recovery."

Magnesium oxide, hydrochloric acid will be produced semicommercially by a new thermal reaction in a plant being built at Sodom, Israel. No process details have been revealed, but *CE* learns that two key phrases would be "salt decomposition" and "thermal reaction in a spray furnace." A complex world-rights contract has been signed between Israel's Ministry of Development and Great Britain's Nordac Co.

Continuous sulfite acid density measurements are possible with a new process-control route, reports a paper delivered before the Canadian Pulp and Paper Assn. Sulfite process liquid passes through a glass loop, where a transmitter weighs continuously, operates over a 0-13.9 Be range, records changes as small as 0.2 Be.

Simplified water-treatment reactor, fashioned of three concentric coaxial vessels, is described in Czech patent 88634, issued to S. Mackerle of Brno. Water containing precipitating agents flows into the innermost chamber; separation occurs as reactor gyrates, and liquid is bled through a slit into the next outer chamber, forming a floc cloud. Excess sludge falls into outermost "thickening" vessel, from which it is drained. Clear water is continuously drawn off.

Extraction of byproduct metals in zinc and lead blende is reported by Societe des Mines et Fonderies de Zinc (Balen, Belgium). Two-step roast yields residue containing recoverable quantities of Cu, Fe, Ag, Cd, Hg, Ge, others; complex route steers residue through a battery of extractors that remove the metals one at a time by appropriate recovery reactions (including electrolysis, blasting, precipitation).

Plants

Bethlehem Steel Co. has announced plans to build a large tar-distillation unit at the company's Sparrows Point, Md., plant. The facility will recover chemicals from coke-oven tar, and it is planned that these in turn will be processed by **Allied Chemical Corp.** at Philadelphia. Input capacity of the Sparrows Point unit will be over 50 million gal./yr. tar, and it is expected to yield over 42 million lb./yr. crude naphthalene as well as tar acids. First shipments from the plant are scheduled for late this year.

Goodrich-Gulf Chemicals, Inc., has awarded the design and construction contract for a 20-million-lb./yr. synthetic rubber plant that the firm will build at Institute, W. Va. The multimillion-dollar unit will produce Goodrich-Gulf's Ameripol CB grade of rubber, and is expected on stream by the end of this year. Contract recipient is the Chemical Plants Div. of Blaw-Knox Co., Pittsburgh.

Air Products, Inc., is building a $6-million oxygen-nitrogen plant at Sparrows Point, Md. Facility will be owned and operated by Air Products, will supply 350 tons/day oxygen and 450 tons/day nitrogen to Bethlehem Steel Co.'s works at that location, as well as additional oxygen (shipped by trailer) to Bethlehem's operations at Steelton, Pa. Scheduled to be completed the middle of this year, the plant will produce oxygen and nitrogen in both liquid and gaseous forms.

Air Reduction Sales Co. has started construction of a $5-million air separation plant at Claymont, Del. Described as the first unit of its type to serve the petrochemical industry, it will be adjacent to new ethylene and ethylene oxide plants of SunOlin Chemical Co. (*Chem. Eng.*, Oct. 31, 1960, p. 58). Airco's plant will be able to produce over 350 tons/day oxygen; initially, about 120 tons/day will go to SunOlin and the rest will be used by other firms in the area. Unit will also produce 25 tons/day nitrogen.

Ohio Oil Co's. subsidiary, Aurora Gasoline Co., plans to start construction late this year on a multimillion-dollar project involving new catalytic reforming and solvent extraction units at Aurora's refinery in Detroit. Main purpose of the project is to help fulfill a long-term agreement recently announced between Ohio Oil and **Dow Chemical Co.,** under which the former firm will supply the latter with 20 million gal./yr. of a benzene-toluene mixture, starting in mid-1962. Dow's aim in making the contract is to stabilize its supply of benzene.

Half of the naphtha feed to Aurora's new reformer will be furnished by other units at the refinery; the rest will be piped to Detroit from Ohio Oil's refinery at Robinson, Ill. Product mixture will be transported by Buckeye Pipeline Co. from Detroit to Bay City, Mich., where Dow is planning to build a unit that will use an undisclosed process in converting the entire mixture to benzene. (Reason for shipping

CPI News Briefs
Continued on page 184

30 alkalies to choose from

This kind of variety is more than sheer spice. It represents higher profits, because you can purchase almost any form and grade of alkali you need. It follows that processing and repackaging costs go down.

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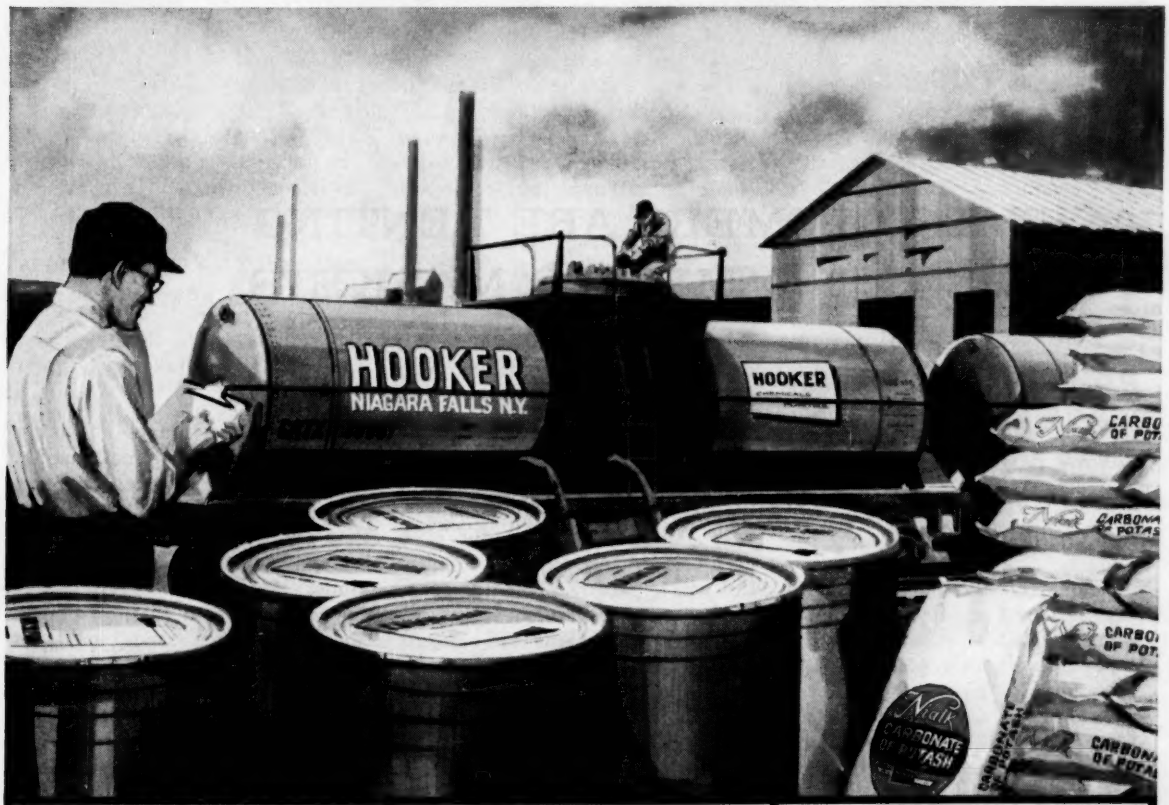
The wider mouth also makes the drums more adaptable to re-use.

The next time you're considering alkali requirements, call in our representative who is trained in the economics of these alkalies. Some of his ideas can work to your advantage.



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Rayon grade liquid 73%
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Fine Flake
Phosphated
Special Alkali

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Standard Grades
Liquid 45-52%
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Flake 85%

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Calcined, Regular Powder 99%
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Calcined, Powder 91-94%
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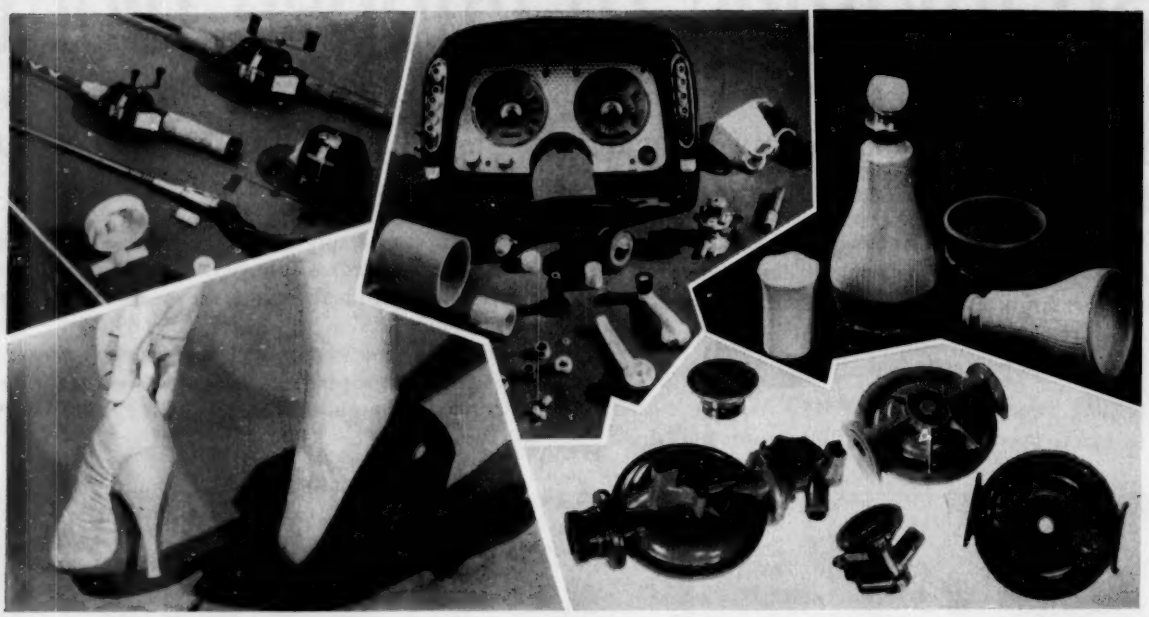


ACETAL POLYMERS ARE DENTING METALS' MARKETS

Recent price reductions are boosting uses of polyformaldehyde resins. New applications turn up at the rate of more than one a day.

Zinc, steel, aluminum and brass are seriously challenged by two lightweight, high-strength plastics that threaten to replace millions of pounds of metals in such volume markets as automobiles, appliances, pipes, containers, hardware, and industrial equipment.

Known as acetal resins, the new plastics, developed independently and almost concurrently by Du Pont and Celanese, are basically high polymers of formaldehyde with unbranched chain structures composed of repeated oxymethylene units $[-CH_2-O-]_n$.

Thermally stable, tough and resilient as spring steel, these acetal resins retain their properties under high temperatures and humidity, even when exposed to most solvents and held under stress for an extended period of time. According to Harold Blancke, chairman of Celanese, ". . . the total market for such high-performance engineering plastics will triple [by 1963] and reach a level of 200 million lb./yr. by 1970." Acetals resins will compete not only with light metals but also with the polycarbonate plastics that General Electric and Mobay introduced last year.

▶ **500-Plus**—Du Pont's product, tradenamed Delrin, was commercially introduced in January 1960, at 95¢/lb. Since that time, the price has dropped to 65¢/lb. and Delrin has found its way into more than 500 commercial applications in which metal replacement accounts for 82% of the total resin poundage.

The material has already penetrated the automotive field to the extent of 44 individual parts in the 1961 models—including a 2-lb. instrument cluster housing that replaces a 9-lb. zinc housing. And commercial uses for the resin are appearing at the rate of more than one a day.

Representative end uses include: flat-top conveyor chains for canneries and bottling plants, door knobs, mechanical parts of home appliances, water pumps, a variety of components for plumbing fixtures, business machine parts, fishing reels, and a host of gears, bearings and cams.

In oilfield piping, another major market area, Delrin is reported very successful for water flood lines, salt water disposal lines and gathering lines because of its 5,000-psi. fatigue endurance limit (the highest for any known plastic), solvent and corrosion resistance, and toughness almost twice as great as other types of high-strength thermoplastic pipes.

Interestingly enough, polyfor-

maldehyde is a plastic that dates back some 100 years, when Russia's Butlerov tried to stabilize the compound—without much success. Trouble was that the aldehyde group at the end of the molecule would hydrolyze and unravel the whole chain when traces of moisture, acids or bases were present.

Polyformaldehyde was finally tamed in recent years after Du Pont poured $50 million (a sum greater than that required for the development of nylon), 300 man-years of laboratory research, and 3 years of field testing with some 250 manufacturing companies.

Today, the resin is suitable for fabrication by injection molding, extrusion, blow molding and other conventional methods on standard processing equipment at mass production rates. It can be fastened with screws, rivets, snap and interference fits, or by welding; and be machined more easily than free-cutting brass.—**E. I. Du Pont de Nemours & Co., Wilmington, Del.** 110A

▶**New Entry**—Not yet commercially available but offered in development quantities at 70¢/lb., Celanese's Celcon is the latest acetal resin now produced.

Unlike the Du Pont product, this new resin is a copolymer based on trioxane (the cyclic isomer of formaldehyde) but with physical, electrical and mechanical properties that closely resemble Delrin.

Hard, stiff and dimensionally stable, Celcon shows long-term resistance to creep and impact forces over a broad temperature range. It can also be molded readily in conventional equipment, withstands molding temperatures (230 C. for 30 min.) in the presence of copper, zinc, iron, nickel, lead, brass and bronze.

Its electrical properties (dissipation factor 0.005-0.004 and dielectric constant of 3.8-3.7 at 10^3 to 10^4 cps.) compare favorably with those of many thermoplastics and, therefore, the resin may find many uses in specialized electrical applications. — **Celanese Corp. of America, New York.** 110B

Urethane elastomer

Resin combines properties of rubbers and plastics.

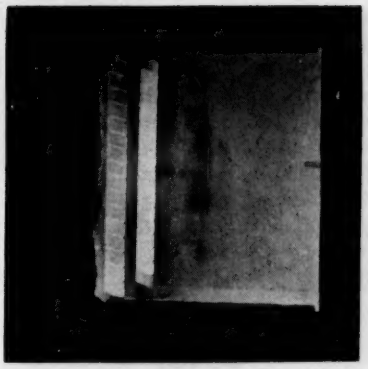
Promising to cut production time of urethane elastomer parts from hours to seconds, new resin Texin can be supplied in different hardness grades that range from soft (for such parts as diaphragms or seals) to so hard that in certain applications the new material has outperformed machined steel.

Texin's major properties are: toughness, resistance to abrasive wear, oils and solvents, plus a combination of hardness with elasticity (i.e. elongation of 500-800% with durometer hardness of 60-65 Shore A, up to 250% elongation at 65 Shore D).

Gears molded of Texin may be made hard enough to transmit energy without appreciable power loss while withstanding stresses and strains that would fracture materials of comparable hardness.

Previously, production of urethane elastomer items entailed a costly, time-consuming liquid-casting method that blocked off huge markets for the mass-produced parts used in the automotive and equipment industries.

Since this new resin lends itself to low-cost injection and transfer molding, market areas have been broadened by extruding urethane elastomer stock for hoses, tubing, profiled channeling and cable jacketing.—**Mobay Chemical Co., Pittsburgh, Pa.** 111A



Silicon heating elements

Product operates at 1,700 C. without protective atmosphere.

Carbide-molybdenum disilicide, known as Super Hot Rod, is an improved heating element developed for use in kilns and furnaces up to 1,700 C.

These rods claim a longer life expectancy at the maximum operating temperatures of conventional silicon carbide heating elements (about 1,500 C.) because of higher resistance to oxidation. In addition, they have an entirely different shape: the hot zone is formed by a spiral that is cut completely through the wall of the tube. This change in shape causes a higher resistivity and the new element can achieve operating temperatures as high as 1,700 C. without even the need for a protective atmosphere. Moreover, the rods can be used with existing power supplies.

Because of their high tempera-

Newsworthy Chemicals

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ture strength, Super Hot Rods may be installed either horizontally (without supports) or vertically, thus giving flexibility in furnace design. They are particularly useful in high-temperature fields such as glass melting, high-speed steel treating, ceramics firing and various laboratory operations.—**Norton Co., Worcester, Mass.** 111B

Briefs

Meta phenylene diamine, an improved intermediate for dyestuffs and a curing agent for epoxy resins, has no ammoniacal odor, offers a setting point of 62.6% minimum, strength to 99.3% minimum, and is insoluble in hydrochloric acid to 0.1% maximum. —**National Aniline Div., Allied Chemical, New York.** 112A

Insulating firebricks M-16, M-20, M-23, M-26, M-28 and M-30, designed to cover exposed service temperatures from 1,600 to 2,900 F., are lightweight and highly porous. Virtually sulfur-free, they withstand direct flame impingement, are said to have met ASTM and military specifications for refractories.—**Kaiser Refractories & Chemicals Div., Kaiser Aluminum, Oakland, Calif.** 112B

Trichloroethyl phosphate, a fire-retardant plasticizer, can be added to PVC, PVA, phenolics, epoxies, polyesters and cellulosics. It can also be used in transparent film applications, coatings and molded products.—**Aceto Chemical Co., Inc., Flushing, N. Y.** 112C

Epoxy-resin hardener, Araldite DP-125, is described as a low-viscosity modified polyamine with excellent elongation properties and resistance to age hardening. Available in sample quantities, DP-125 is a curing agent for liquid epoxy systems.—**Ciba Products Corp., Fair Lawn, N. J.** 112D

Dielectric fluid coolant may offer extreme low-temperature capabilities in liquid-cooled electronic equipment. Thermally stable to 400 F. and pumpable when as cold as −85 F., the trademarked Coolanol 35 has a dielectric strength of 47 kv. (rated at 25 C.).—**Monsanto Chem. Co., St. Louis.** 112E

Tantalum powder is reported to improve the fabrication and performance of electrolytic capacitors. Called SGP, the highly pure powder makes lower-density pellets possible, thus increasing capacitance/gram. — **National Research Corp., Cambridge, Mass.** 112F

99.999+%-pure silver for semiconductor and other applications has been produced by a new atomic recombination process, details of which haven't been disclosed. The only spectrographically detectable elements that are present in the ultrapure metal are iron, copper, silicon and manganese—each in quantities smaller than 1 ppm.—**High Purity Metals, Inc., Hackensack, N. J.** 112G

Caulking compound makes dependable joints between mismatched materials such as metals, plastics, concrete, tile. Named Epocaulk, the epoxy-based compound is troweled into place, requires no heat for cure, sets without shrinkage to a tough, corrosion-resistant solid. — **Adams Chem. Corp., El Segundo, Calif.** 112H

Polyurethane foam insulates over a 500 F. span

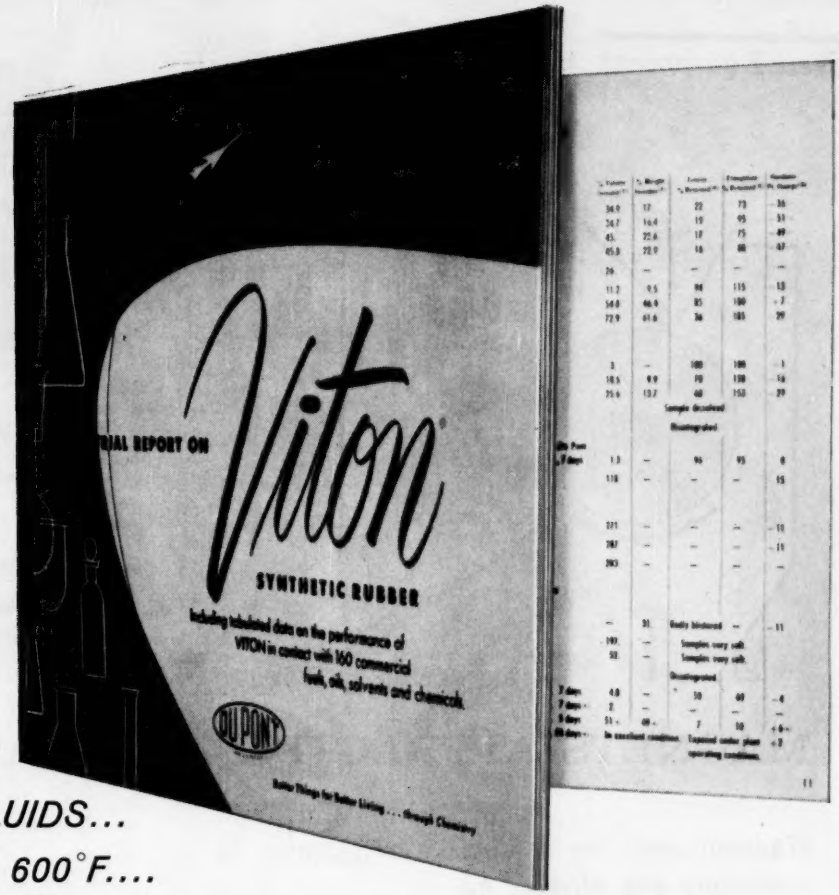
Glued to the roof of this cold-storage warehouse, the dark slabs consist of a layer of cellular glass combined with a new polyurethane foam that gives effective thermal insulation from −330 F. to more than 200 F.

Known as Foamthane, the rigid polyurethane material has a density of 1.6-2 lb./cu. ft.—about as dense as polystyrene foam is, but with twice the insulating value. Foamthane has a K factor averaging 0.14, compared with polystyrene foam's 0.28.

Resistant to most solvents (especially gasoline and other hydrocarbons that dissolve polystyrene), the new foam is also described as verminproof, odorless and nontoxic.

Because of its insulating efficiency at low temperatures, Foamthane is reported particularly suited to freezer or cold-storage applications.—**Pittsburgh Corning Corp., Pittsburgh, Pa.** 112I

For more information about any item in this department, circle its code number on the Reader Service Postcard (Page 209)



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In a refinery valve, *seat and O-rings of* VITON *still give positive shutoff after more than a year's service with benzene!*

In a tank farm loading system, VITON *packings have handled a wide range of solvents, both aromatic and aliphatic, for over two years without deforming or losing their resilience!*

THESE are just a few of the many industrial applications where VITON synthetic rubber is cutting operating costs, doing jobs no other rubber could do. "Industrial Report on VITON" brings you more examples, plus latest engineering facts and figures on Du Pont's improved heat and fluid resistant elastomer. Here's a brief summary of its contents:

COMPLETE HEAT AND FLUID RESISTANCE DATA—Seals, gaskets, hose and other products made of VITON perform at temperatures from −40° F. to +600° F. "Industrial Report on VITON" gives more details, and outlines VITON's resistance to 160 commercial fluids.

PHYSICAL AND RESISTANCE PROPERTIES—Information is provided on hardness, tensile strength, elongation, compression set, electrical and low temperature properties, as well as resistance to ozone, weather and sun.

This reference booklet should be in *your* permanent materials file. Fill in and mail the coupon below for your copy. For information on specific parts made of VITON, and how they can cut your operating costs, see your rubber goods supplier. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department CE-4, Wilmington 98, Delaware.

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VITON®
SYNTHETIC RUBBER

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Elastomer Chemicals Dept. CE-4
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Please send me a copy of
"INDUSTRIAL REPORT ON VITON SYNTHETIC RUBBER"

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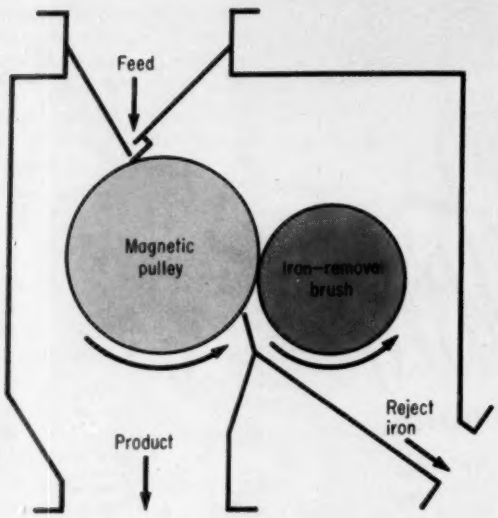
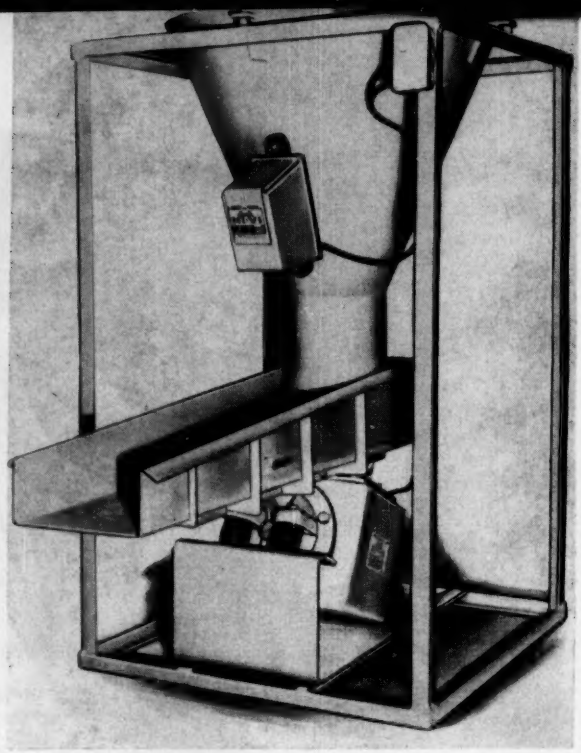




MAGNETS ATTRACTIVE FOR VARIED USES

Magnetic units for feeding, separating and filtering become more sophisticated. Old principles in new garb yield faster, more accurate material moving, separation.

While magicians perform feats with manacles, mirrors and magnets, in industry the magnets attract even greater attention, find more diverse application. Some of these uses are demonstrated by four devices just introduced by the Eriez Mfg. Co., Erie, Pa., which specializes in magnetic equipment.

A separator automatically removes fine iron contamination from materials in the range from 10 mesh to extremely fine powders. Contaminated material passes over a high-intensity magnetic drum that combs the material and pulls fine iron away from the product.

As the drum revolves, the iron-free product spills into a discharge chute; the iron particles sticking to the drum pass a flexible baffle that sweeps clinging powder into the same chute. On the other side of the baffle, a brush—revolving at high speed countercurrent to the drum—knocks the iron particles off into a separate chute.

The unit may be set up in two or more stages for particularly difficult separations. Separation efficiency on Fe_3O_4 contamination is said to be 98-100%. On weakly magnetic FE_2O_3, up to 95% of the ferrous material is removed.—**Reader Service No. 114A**

• Precise delivery of dry bulk materials is promised with the "volumatic feeder," designed for small batch operations or for use where additive feeding is performed continuously or intermittently.

Built-in hopper has separate magnetic vibrator that insures flow of bulk material to a feeder mounted directly below it. The feeder is driven with a vibrator that replaces the usual rectifier with a permanent magnet, so that a.c. power is used directly.

Various timers are optional equipment for controlling timed or intermittent feeding phases. Feeder has dual control for fast and dribble feed rates. Capacity range is 1 to 10 tons/hr.—**Reader Service No. 114B**

• Similar to the feeder described above but a separate unit without the hopper, a new vibratory feeder has moisture- and dust-resistant drive elements that can be specially constructed for operation in extremely hazardous or dusty locations. Delivery is usually accurate within ±2%; output can be varied from zero to full capacity by a simple control. Vibratory action ceases instantly when power is turned off, so delivery cutoff is precise without "run down" dribble from delivery spout. Capacity

Magnet-filter traps iron particles, screens out solids in fluid stream.

if it's in bulk...

TOTE SYSTEM*

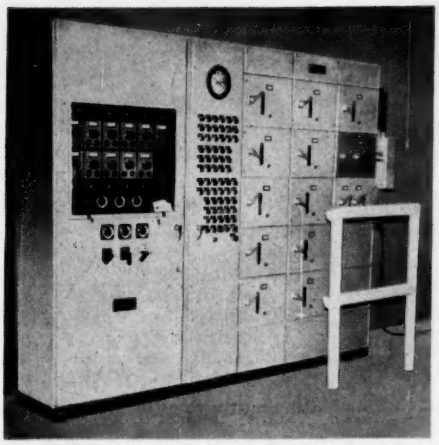
and only Tote will handle it

in-plant or inter-plant

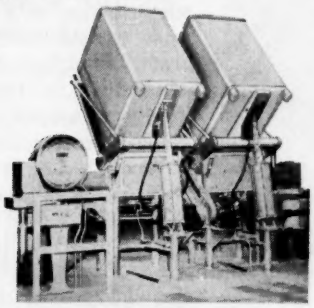
with the efficiency and economy of automation

the flexibility and versatility of unit containers,

and the product protection of sealed containers



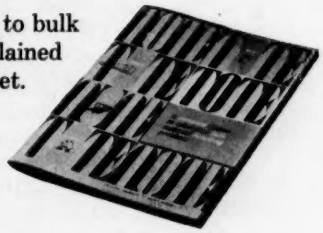
Automatic control panel programmed to weigh 12 ingredients from 12 Tote Discharge Tilts into one mixer.



Two Tote Bins discharging from Tote Tilts into automatic weigh hoppers.

TOTE is a complete, mechanical, fully automatic system based on metal containers plus filling and discharging equipment.

The Tote System answers to bulk handling problems are explained in detail in this new booklet.



Write for it TODAY

TOTE SYSTEM, INCORPORATED

600 So. 7th, Beatrice, Nebraska

Subsidiary of Hoover Ball and Bearing Company

*TOTE AND TOTE SYSTEM Reg. U. S. Pat. Off.

ranges from ½ to 10 tons/hr. and up—Reader Service No. 114C

• Final item is a new magnetic trap-filter that pulls iron from flowing liquid streams, simultaneously strains out solid nonmagnetic particles down to 0.020-in. dia. Built to withstand 150 psi., unit fits 2-in. pipes, can be adapted to any line down to ½-in.

Fluid flow may be directed to pass magnet, then go through filter, or vice versa.—Reader Service No. 114D

Blending System

Electronically controlled unit monitors flow on total volume.

A new system for inline blending of two or more fluids depends on total volume measurement and ratio rather than flow rate, hence minimizes variations in component flow rates. Accuracy is said to be about ± 0.5% of each stream reading, and ± 0.2% for reproducing a given blend.

In operation, standard turbine flow meters measure the volume of fluid fed in each stream, signal amount to electronic controller. This equipment, programmed to control the streams at a preset ratio, calculates the total amount of each component already in the blend, adjusts the various feed rates to bring the total volume ratio back to the set point if there is any deviation.

The advantage claimed for this system over one based on flow ratios is that ratio adjustments are made to insure a final blend of the proper proportions. In flow rate systems, control is on instantaneous flow ratios; if an upset does occur, flow ratios are adjusted but there is no compensation for the error introduced.

Various systems are offered that not only provide basic control but convert flows to engineering units, shut down equipment when a specified batch is completed, and give analog flow rate indication of each component.—**Fischer & Porter Co., Warminster, Pa. 116A**

Data processing system

Computer cuts programming time, uses special input language.

A new computer, said to be designed to close the gap between programming and machine speed, not only can process two or more programs at the same time but also schedules and keeps track of its own work load and advises its operator if it makes a mistake.

Called the B5000, the system accepts both ALGOL (algebraic language) and COBOL (common business language) from its programmers. This enables users to communicate with the machine in the language of the problem rather than in complex numerical codes. Programming personnel are trained more rapidly and can prepare input data with less experience than is required for conventional programming.

The computer will rent for $13,500 to $50,000/mo., depending on the size of the system. Entire system is designed in module form so installations can be expanded as computer load requires.—**Burroughs Corp., Detroit. 116B**

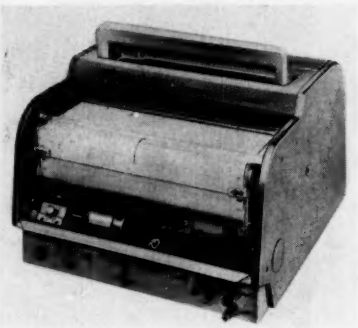
Difference counter

Instrument measures two variables, instantly indicates difference.

Wherever it is desirable to monitor two different variables and find the difference between them, a new electronic measuring device can do the trick. Called a "difference counter," it measures the variables simultaneously and provides instant visual indication of their difference.

Typical applications might be to monitor two different shafts to maintain a desired rpm. difference between them. Should one or the other overrun or fail to maintain its required speed, the device would discover the situation and react to make necessary corrections or shut down the operation.

The unit can be equipped to read instantaneous variance in angle of degrees, rpm., inches, feet or many other increments of measure.—**Post Electronic Products, Beverly, Mass. 116C**



Recorder

Chromatograph unit automatically integrates area under printout.

Quantitative analysis by gas chromatography usually involves measurement of areas under each peak on the recorded chromatogram. But this recorder automatically integrates these areas while the chromatogram is being printed.

Key: two pens. One is the conventional recording point, the other an integrating one. When the recorder pen leaves the zero line to start a peak, the integrator leaves its zero line and starts plotting the cumulative area under that peak. When the peak is completed, the integrator stops at a reading proportional to the total area; and once it's traveled the full width of the chart (which is 1,000 counts), it automatically reverses.

Counting rates of 10, 20 or 40 chart-widths (i.e., up to 40,000 counts) per min. are possible by shifting gears. Integrator curve can be started from either side of the 9½-in.-wide chart and either

National Carbon Design Engineers multiply your engineering staff

C. E. HULSWITT
Design Engineer

Mr. Hulswitt, since becoming associated with National Carbon Company in 1956, has been instrumental in the design and development of an extensive variety of "Karbate" impervious graphite chemical process equipments.

One of the design areas in which Mr. Hulswitt has been particularly active is that of hydrogen chloride combustion, absorption, and stripping.

Mr. Hulswitt was graduated from Purdue University with a B.S. degree in Chemical Engineering.

New Catalog Section Describes "Karbate" Counterflow Block Heat Exchanger

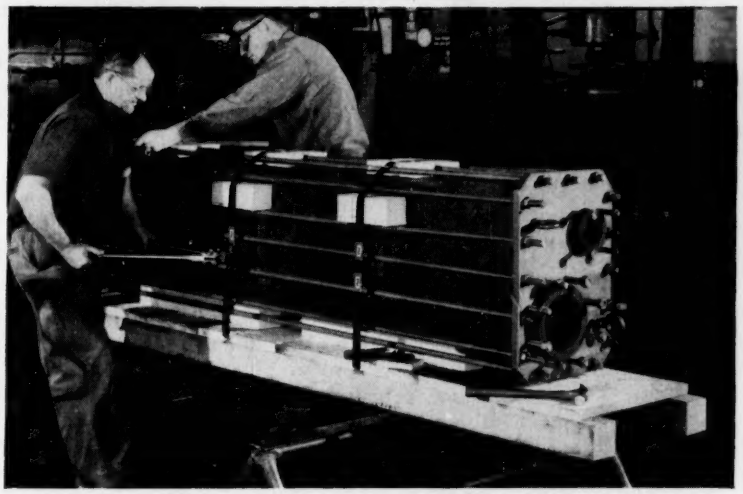
A detailed description of "Karbate" impervious graphite heat exchangers Type CFB is presented in a new, 8-page Catalog Section—S-6813.

Information on this new, advanced-design, corrosion-resistant unit includes operating features, specification data on single and multi-pass models, construction and dimensional data, fluid flow patterns, pressure drop characteristics, and mounting methods. The catalog is fully illustrated with photographs, diagrams, and graphs.

Utilizing center blocks of impervious graphite, "Karbate" heat exchangers Type CFB provide the most versatile and dependable method of processing corrosive materials.

Write today for your copy of this timely, comprehensive publication. Ask for **Catalog Section S-6813.**

New "KARBATE" Condenser Type CFB on Way to Handle a Highly Corrosive Application



This new single-pass, three-pass unit is being prepared for shipment to a Midwestern chemical company for condensing an organic from an acid steam distillation operation. Fluids on both sides of 90 square feet of heat transfer surface contact "Karbate" impervious graphite only.

"Karbate" impervious graphite Type CFB is the newest cost-saving advancement in heat exchangers.

Measuring only 13 inches x 21 inches in cross-section, Type CFB (when mounted vertically) provides more heat transfer area per square foot of floor space than any other block type exchanger.

In addition to the unsurpassed corrosion resistance of "Karbate" impervious graphite and the high thermal efficiency of true counterflow design, Type CFB permits maximum flexibility in change of heat transfer area. Center blocks, each 23 inches long, can be varied from 1 to 6 to provide a range of areas (for 3-pass unit) from 37.3 to 172.8 square feet. Single or multi-pass units give dependable operation at pressures up to 100 psi.

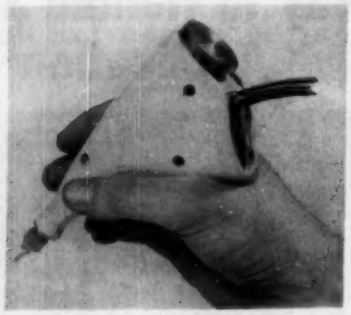
Other "Karbate" Equipment for Chemical Processing Systems

For incorporation in systems for the external heating or cooling of corrosive solutions used in plating, pickling, anodizing, and cleaning, "Karbate" impervious graphite is available in products and equipment such as: Pipe, fittings, and valves . . . for long life, easy installation, minimum maintenance.

Centrifugal pumps . . . frame-mounted and motor-mounted . . . available in 22 models serving a wide capacity range.

Other major items of "Karbate" impervious graphite include: Shell and tube heat exchangers, HCl systems, absorbers, combustion chambers, entrainment separators, and cascade coolers.

reset between peaks or allowed to continue with a section for each peak. Accuracy is said to be ± 0.5% full scale.—**Fisher Scientific Co., Pittsburgh.** 116D



Tool marker

Vibrator writes like a pencil on glass, leather, plastics, metals.

Electrical vibrator permanently identifies such diverse items as tools, heavy machinery, production parts, plastic piping. Carbide point vibrates 7,200 times/min.; device is cased in unbreakable polypropylene. Control wheel adjusts for fine, medium or coarse stroke.

Partial list of materials the tool will write on: metals, marble, glass, plastics, leather, ceramics, hard rubber.—**Burgess Vibrocrafters, Inc., Grayslake, Ill.** 118A

Rubber pail

Bucket holds 3 gal. of concentrated acids, alkalis, or corrosive salts.

Light, shockproof and rigid, this hard-rubber pail will "resist" the attack of hydrofluoric acid up to 50% concentration, nitric acid up to 20% at room temperature, hydrochloric acid of any strength, potassium hydroxide up to saturation.

Graduated markings on the inside of the pail provide quick measurement of contents from 1 to 12 qt. Safety features include hard-rubber pour grip, permanently secure molded-bearing handle, reinforced bottom. Fabricated from a virgin-rubber base, pail wont crack or chip in ordinary use.—**Stokes Molded Products, Trenton, N. J.** 118B

System monitor

Electronic watchdog guards 200 process points, signals trouble.

Designed to oversee as many as 200 high or low temperatures, pressures, flows, levels or contact closures at the rate of 5 points/sec., a new instrument can monitor any input that can be represented by d.c. voltage as low as 10 m.v. full scale.

Display lights on the "alarm indicating monitor's" control panel indicate that an out-of-limit condition is occurring at a specific point. Simultaneously, a horn sounds. This is silenced by an acknowledgment button, but the alarm light will remain lit until the condition is corrected by the operator.

Limits are set by inserting pins in a pinboard. Alarm accuracy is ±0.1% of full scale while manual readout of any point, accurate to ±1% of full scale of the increment selected, is available continuously. A meter indicates the reading of the variable for the point selected manually, holds the reading for 2 sec. During the holding time, the system scans 10 other inputs.—**Hagan Chemicals & Controls, Pittsburgh.** 118C

For More Information about any item in this department, circle its code number on the Reader Service Postcard (Page 209)

Bin liner

Porous steel panels prevent bridging, speed solids flow.

Bridging, caking, and uneven flow rates from bins are eliminated with a new flow-inducing system consisting of porous stainless steel plates mounted in the critical areas of the bin. Serving as a distributor for a small amount of fluidizing air or gas, the panels provide a gas-coated frictionless bin wall.

Only about ½ cfm. of fluidizing gas is required for each panel. Where additional aeration is needed, perforated probes are placed in the bin above the panels.

Flow from bins containing the system is at least three times greater than from ordinary ones used to store many slow-flowing materials—and the fluidized flow is uniform rather than uneven.

When used in conjunction with an automatic feeding device, the panels insure an even supply of the bulk material to the feeder, hence allow it to operate with maximum accuracy.—**Pall Corp., Glen Cove, N. Y.** 118D

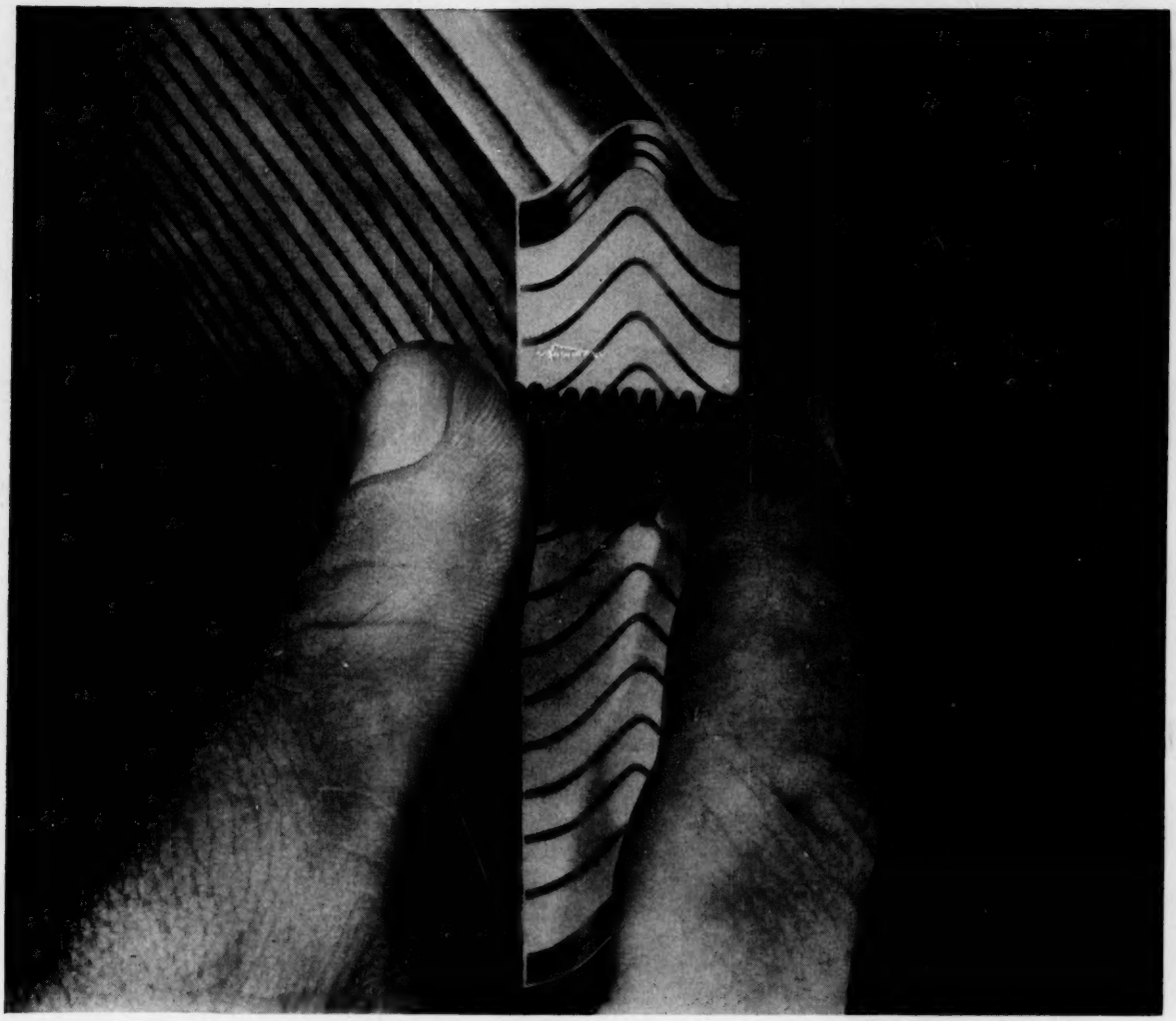
Urethane insulation

Rigid foam is being tested as an insulator on railroad tank cars.

A 4-in.-thick jacket of rigid urethane foam is expected to yield "much better" insulation on railroad tank cars that carry, for example, urea-formaldehyde solutions at 77 F. Now under investigation, the sprayed tank shells appear to stand up well under the flexing and jolts of normal tank car service.

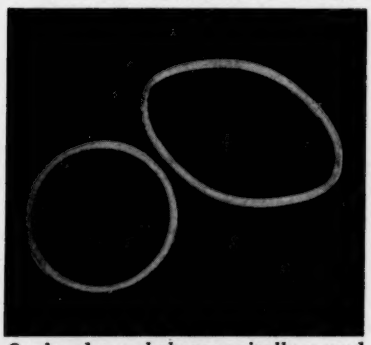
For tests, about 575 lb. of 2½-lb.-density foam have been sprayed over 4,000-gal. cars in a layer weighing 1 lb./sq. ft. (Insulation and steel outer jacket now used in railroad tank cars weigh about 6 lb./sq. ft.) If the new insulation proves out, practical advantages (besides light weight) would in-

New Equipment continued on page 194



"Spring Action" gives you a leakproof seal with J-M SPIROTALLIC® GASKETS

Johns-Manville makes a specialty of building a lively "spring action" into Spirotallic Gaskets. Because of their superior resiliency, Spirotallic Gaskets can compensate for varying stresses and temperature changes ... follow minor flange separation ... and absorb vibration. Even under these difficult circumstances, they keep a tight, durable seal.



Oval and round shapes spirally wound

This quick adaptability has given Spirotallic Gaskets a tremendous popularity in the field. Their springiness is due to the special methods and control J-M uses in their manufacture. Spring-like metal strips, formed into a special vee shape, are alternately spiral-wound with an asbestos filler. The filler does the sealing . . . and the vee shape provides the "spring."

Another reason for the widespread acceptance of Spirotallic Gaskets is the fact that when the gasket has been compressed the proper amount, it reaches optimum performance for the bolting. Many different metals and fillers can be used. Each metal is color-coded to aid maintenance personnel in quick identification of the type of metal used.

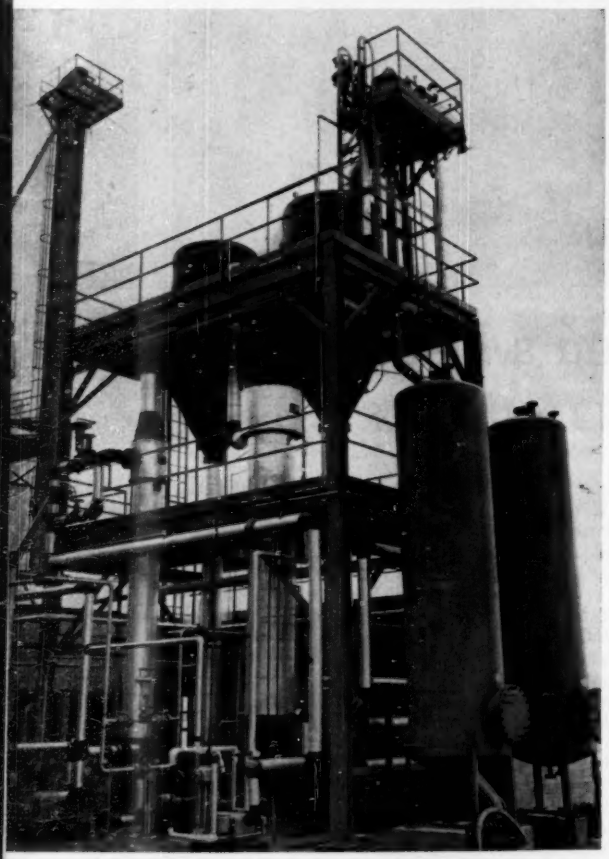
J-M produces a wide variety of sizes and shapes for standard flanges. And for special flanges, J-M will design and produce a gasket with the precise characteristics you require. For complete information, ask for J-M catalog PK-35A. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Bzura Chemical Co. enters citric acid manufacture with a process boasting low raw-material costs and a short fermentation cycle.

New Contender Enlivens Citric Acid Picture

N. P. CHOPEY, *Assistant Editor*



Final processing starts in evaporators that concentrate acid solution for crystallization.

It's official now: there are three big contenders for sales accounts in the U.S. citric acid market.

With startup difficulties solved and its much-heralded Fieldsboro, N. J., plant on stream, Bzura Chemical Co. has joined long-standing Chas. Pfizer & Co. and relative newcomer Miles Chemical Co. as a producer of the organic acid for industrial use.

Long a quiet area, within the domain of Pfizer, citric acid began making news in 1958 when Miles Chemical entered the picture. A new company, created by a corporate move of Miles Laboratories, Inc., it decided on the basis of market surveys that there was room for another producer in the U.S. citric industry. And it felt well qualified to enter the field, because Miles Laboratories had been making citric acid as an intermediate in Alka-Seltzer manufacture since 1952, in a 7-million-lb./yr. plant at Elkhart, Ind.

The new firm began expanding the Elkhart plant, stopped at a level of 15 million lb./yr. in October 1959. Now, part of Miles' output is used captively, and the rest is marketed.

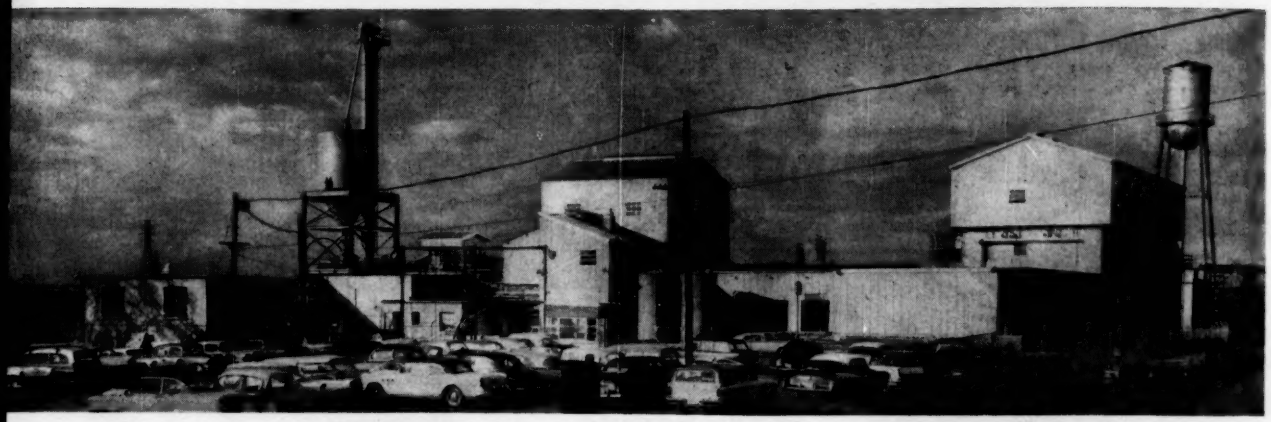
▶ **Enter Bzura**—First notice of the third contender came around the time that Miles was dedicating its expanded plant. Bzura, an organic chemicals manufacturer headquartered in Keyport, N. J., announced it was building an 8.5-million-lb./yr. citric facility at Fieldsboro, would come on stream with a process that realized big economies mainly by being able to use crude, cheap blackstrap molasses as raw material, and cutting fermentation cycle time. Before the plant was completed, company was able to up capacity to 16 million lb./yr. through modifications piloted at Keyport.

Incorporation of these changes, coupled with personnel problems, postponed the start of commercial operation until early this year. Bzura declares its startup difficulties were connected with equipment in downstream purification of the acid, not with steps in the company's fermentation operation.

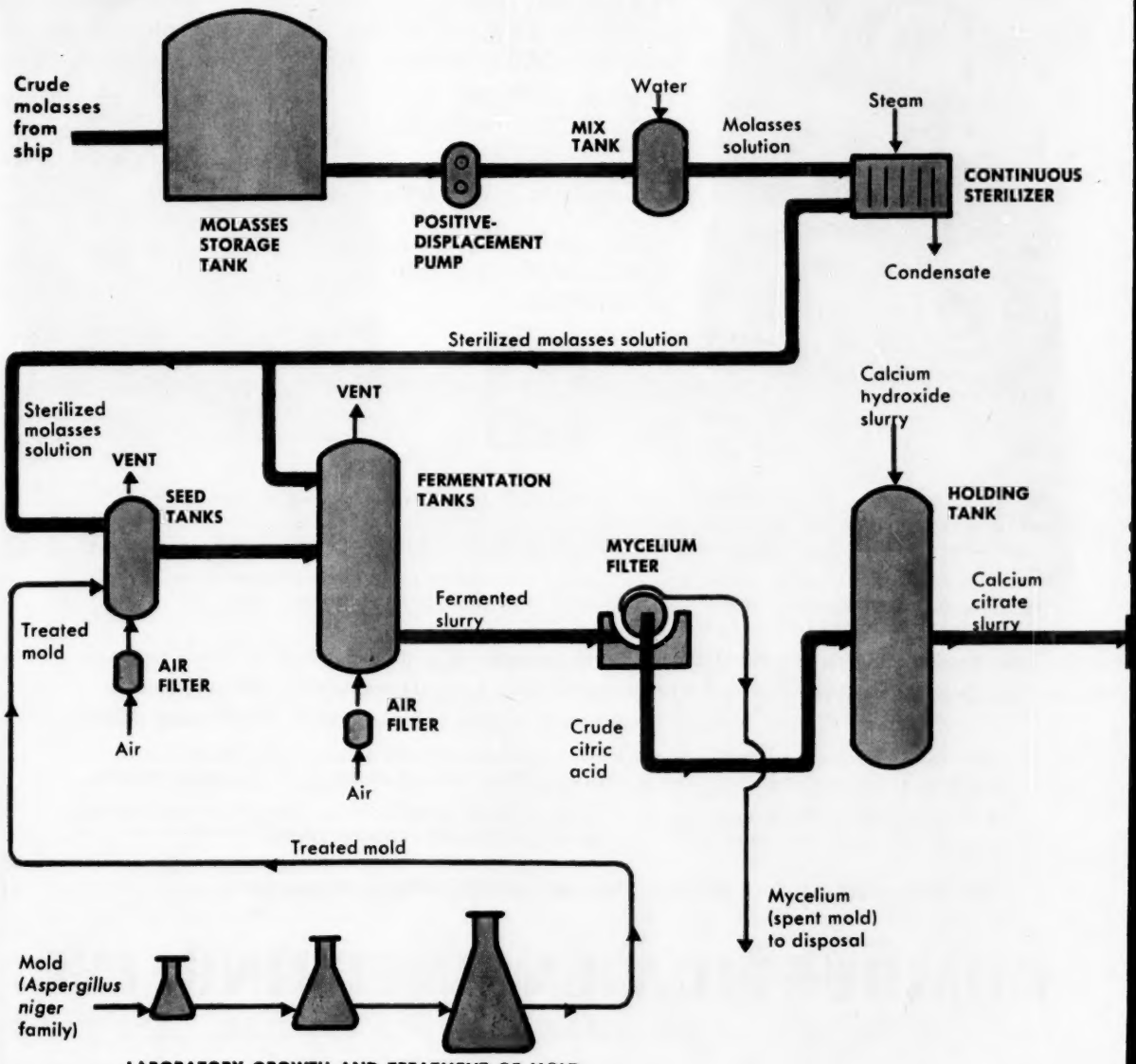
▶ **The Citric Picture**—Citric acid finds its main outlet as an ingredient in food mixes for desserts and fruit beverages. Other uses for the acid and its related compounds are in making pharmaceuticals and cosmetics, as well as in water conditioning, metal pickling and production of vinyl resins (as a plasticizer or foam inhibitor). Bzura estimates the current U.S. market to be 80 million lb./yr.

Pfizer, Miles and Bzura all make citric acid by fermenting molasses, using varieties of *Aspergillus*

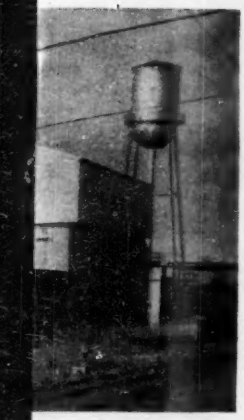
Unfold flowsheet



New plant was sized to produce 8.5 million lb./yr. Later process modifications led to near-doubling of this figure.



LABORATORY GROWTH AND TREATMENT OF MOLD



g of this figure.

niger mold as culture. Latter two firms use the so-called deep-fermentation technique, in which the operation takes place in vertical tanks. Pfizer has worked with deep fermentation but mainly uses the classical shallow-pan system.

All three companies are chary with process details, perhaps because fermentation is still considered an art rather than a science in many respects. Main areas of secrecy are the mold preparation and actual fermentation steps. Bzura, for instance, gives a good description of its over-all processing sequence but will say almost nothing about how it prepares the culture, and little more about its fermentation.

► **Features**—Preparation of the culture consists of laboratory treatment of the *Aspergillus niger* strain with undisclosed chemicals. This treatment is the key to Bzura's process advantages.

Foremost advantage is that the firm can use widely available crude blackstrap molasses as starting material. This not only provides an attractive raw-material cost situation, but it also permits a broad choice of locations throughout the world for future plants.

Shorter cycle time is the other big advantage—Bzura claims its process cuts 25% off the normal period (6-9 days, according to one source) required for seeding and fermentation. Result: lower fixed cost per pound of product.

Also, Bzura—like Miles—doesn't obtain oxalic acid as a fermentation byproduct. Pfizer reports that its operation does yield some oxalic; the firm markets the material but tries to minimize the amount produced.

Finally, downstream processing and purification at the Fieldsboro plant are unusually straightforward, with a minimum of treating required.

► **Following the Process**—Bzura receives its molasses by tanker, stores the material in a 3-million-gal. tank. A positive-displacement pump transfers the feedstock through 18-in. lines to a mix tank that holds about 100 gal. Water is added here to produce a 50-75% molasses solution.

A steam-heated continuous sterilizer, resembling a plate-type exchanger, heats the material to 248 F. and then cools it to an exit temperature of 77-95 F.

In the meantime, the *Aspergillus niger* strain has been growing in the laboratory. Following the undisclosed laboratory treatment, it is introduced together with the molasses solution to one of a group of 3,000-gal. seed tanks. After fermentation is well under way, the mixture goes to 30,000-gal. stainless steel fermentation tanks.

Filtered air passes through both groups of vessels during the operation. Bzura isn't revealing the amount of air used or the method by which it is distributed. The fermentation takes place in the standard range of 77-95 F., and the vessels operate under a pressure of 15-30 psig.

► **Purification**—Resulting crude citric acid solution goes to a rotary filter having about 250 sq. ft.

CONTINUOUS STERILIZER

ensate

de

HOLDING TANK

Calcium citrate slurry

CALCIUM CITRATE FILTER

Calcium citrate cake

Sulfuric acid (93%)

WEIGH TANK

Citrate-free filtrate to disposal

Calcium sulfate slurry (in citric acid solution)

CALCIUM SULFATE FILTER

Calcium sulfate

Citric acid solution

Calcium sulfate cake to disposal

Charcoal

Citric acid solution

MIX TANK

DECOLORIZ FILTER

Spent charcoal to disposal

filter area, which removes mycelium (spent mold growth). The company discards the mycelium now, hopes to find an outlet for it as animal feed.

Clear liquor goes to a 30,000-gal. holding tank where it is combined with a slurry of calcium hydroxide that converts the citrate content to water-insoluble calcium citrate.

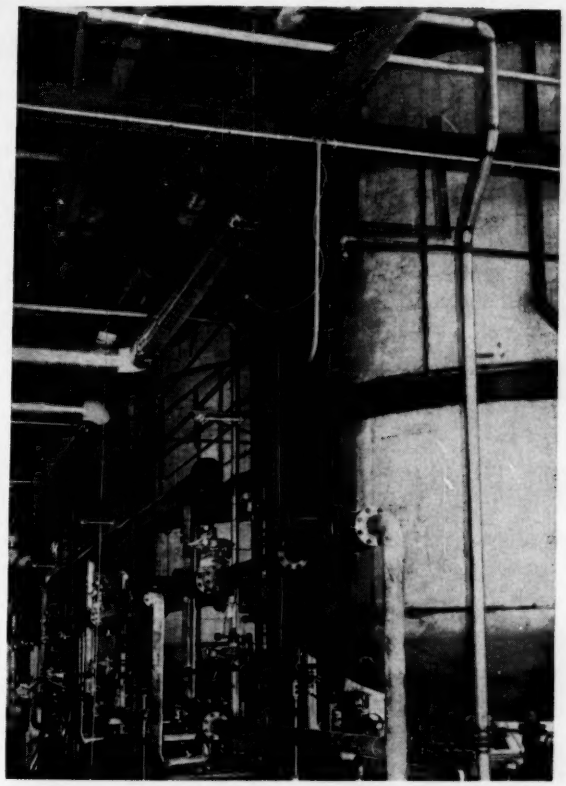
A rotary filter recovers this citrate, after which the material drops into a 10,000-gal. weigh tank where it reacts with 93% sulfuric acid. Reaction takes calcium out of solution as calcium sulfate, reconverts the citrate content to citric acid. A third rotary filter removes the sulfate, which is then discarded.

Filtrate is combined with charcoal in a mix tank for decolorizing, and the resulting slurry then passes through a leaf filter.

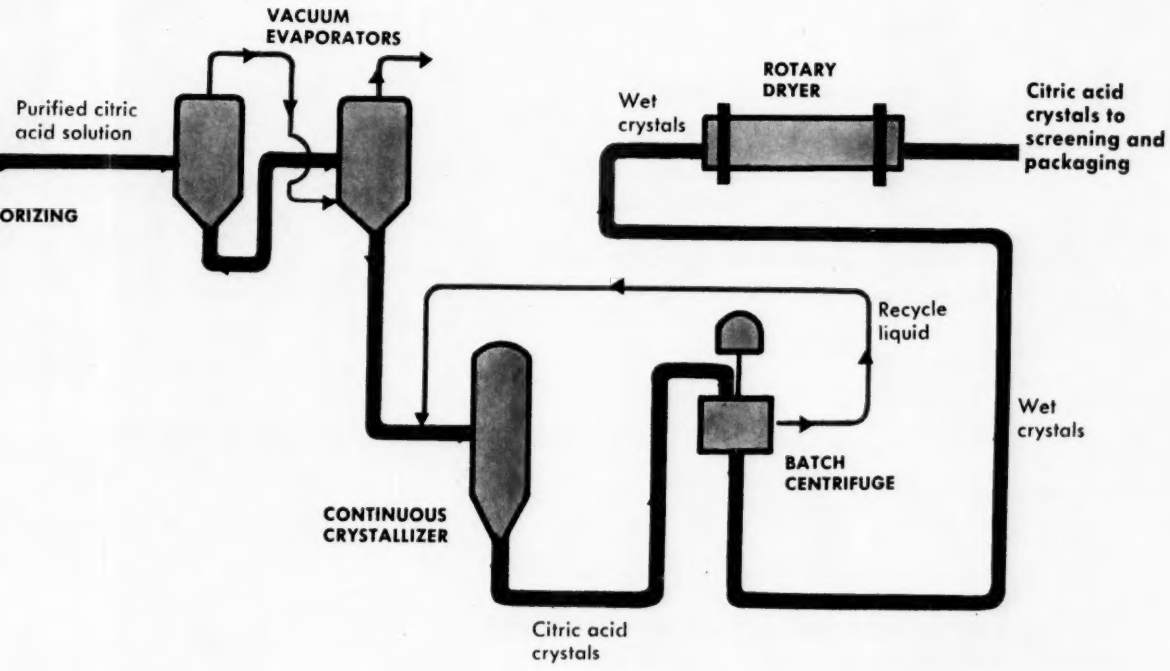
► **Finishing Up**—Clear liquor from the leaf filter is a pure, 20% solution of citric acid. A double-effect vacuum evaporator system, operating at 120-125 F., concentrates the solution to 60-70%, and the stream then goes to a crystallizer.

The crystallizer yields anhydrous crystals if it is operated at about 98 F., or the monohydrate form at lower temperatures. In either case, product crystals go to a batch centrifuge where they are washed with water, then to a rotary dryer. Final steps are to classify the crystals by screening, then package the product.

Over-all process yield: 80-90%, based on the sugar content of the entering molasses.



Key area of plant is bank of vessels in which fermentation yields the crude acid from molasses solution. Tanks are made of stainless steel, hold 30,000 gal. each.



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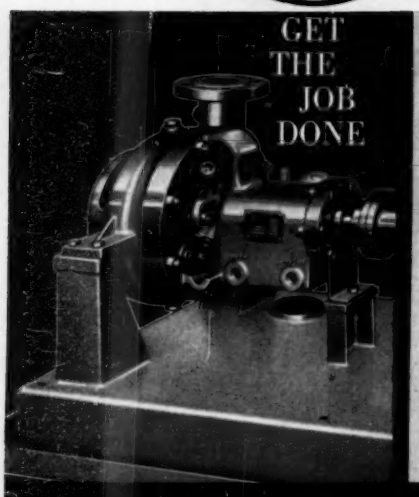

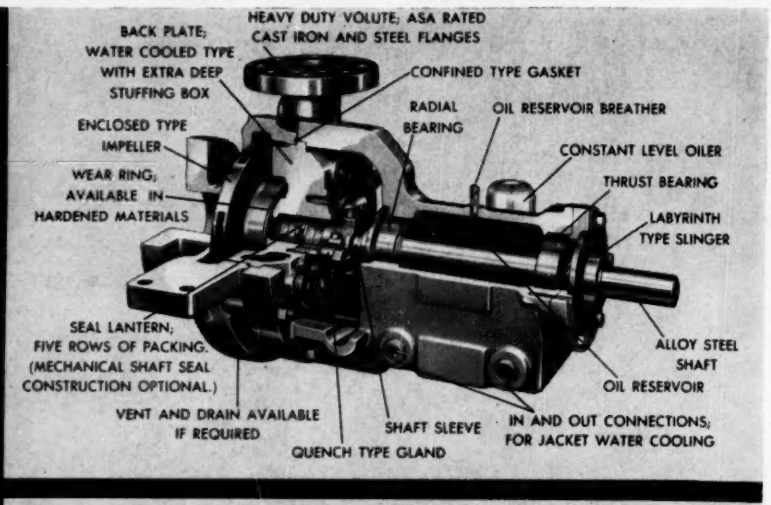

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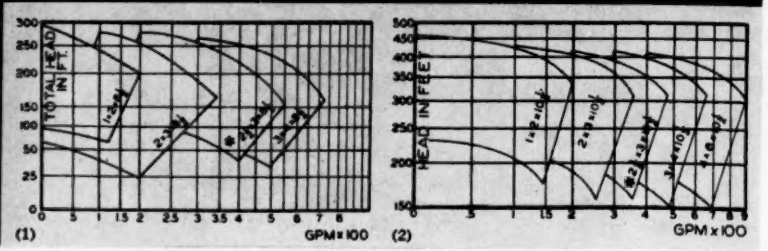

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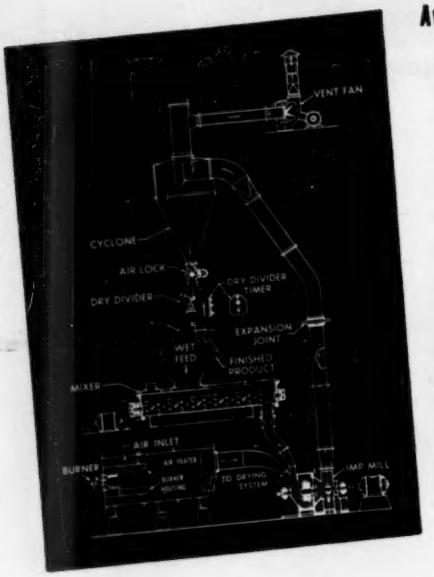

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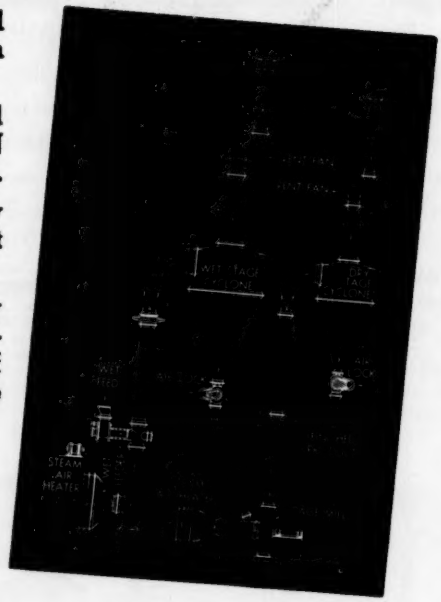

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SARCO TOPICS

A FAMOUS FLUID WITH TEMPERATURE CONTROL PROBLEMS

Wine has never been properly appreciated by enough people. Many think you simply press grapes, bottle the juice, and wait a while to create wine. Even those who pride themselves on their knowledge of this age-old drink are seldom aware of the artful thermal engineering required. Pasteurizing wine is actually one of the most tricky and delicate feats in the field of liquid processing.

Take temperatures. Wine must be pasteurized at 140°F. Those are the facts of life in the world of wine. They might not seem too difficult to live with unless you're in the wine or chemical processing business.

Take New York's Monarch Wine Company, producers of Manischewitz Wine. Their Problem: how to maintain the 140° temperature in the heat exchangers despite wide variations in the rate of wine flow. These variations, between 5 to 60 gallons per minute, result from slowdowns and recoveries in the bottling process. Problem: entire system must be capable of complete shutdown when necessary. Problem: wine temperatures must be raised to 140° as rapidly as possible, sometimes an immediate jump of 100°

Attracted perhaps by aspects of the situation that had little to do with pure science, Sarco engineers applied the collective experience of Sarco technology to the solution of this serious problem. The result for Monarch: the *degree of control* the process demanded—achieved through the excellent use of Sarco Temperature-Pressure Regulators, Float Thermostatic Steam Traps, Thermo-Dynamic Steam Traps, and Pipeline Strainers.

Sarco engineers, ever resourceful, divided each of the two large Cherry-Burrell plate-type heat exchanger units into two separate sections with a blank baffle plate, each with a separate Sarco control. Thermal sensing bulbs were installed in wine discharge and throttling controls hooked into steam supply. As demand fluctuates, one or both regulators function to maintain the 140° temperature.

In higher demand, both regulators are operative; as demand drops and flow decreases, only one regulator supplies steam. Pasteur himself would have been elated.

Each of six smaller capacity shell-and-tube heat exchangers required only one regulator, with the sensing bulb inserted into the outlet side of the wine filled shell, and the regulator throttling steam supply to the tube section. Thus, by controlling flow of steam to the exchangers on the basis of pressure and temperature, the Sarco regulators were able to maintain the temperature of the wine at precisely 140° regardless of fluctuations in demand or supply rate. Whew! A lot of engineering went into those two sentences.

From here on it's downhill. To secure complete cut off of the steam supply during scheduled shut-downs of the bottling run, solenoid valves were provided to supplement normal modulating action of the controls. To discharge widely varying loads of condensate continuously and remove immediately all air and incondensible gases, Sarco Float Thermostatic Steam Traps were installed on all condensate outlets. On the drips before each control valve a Sarco Thermo-Dynamic Steam Trap was installed to insure delivery of dry steam. Sarco Pipeline Strainers were installed before all steam traps and valves to protect them against damage by any foreign bodies. And thus ends a classic story of the grape.

Still, this story has been condensed far too much, really, and we feel you've been cheated out of the story's more delicious details. You needn't be, however. We've printed the facts in detail for posterity and you in Sarco Case History 185, complete with drawings that practically make it a do-it-yourself kit. If you would like a copy, we will be flattered to receive your request, and dispatch it with dispatch.

WE'RE ALWAYS IN . . . AND THE WELCOME MAT'S OUT

We always take it for granted that if you are going to be in the vicinity of our plant you'll phone or drop us a line so we can invite you to visit us. You'll find that our factory in Bethlehem, Pennsylvania, is on many well-travelled routes and that our steam laboratory has much to offer in interest and helpfulness. Forgive us for being immodest, but the lab is the most up-to-date of its kind in the country.

When you visit us, don't allow yourself to get sidetracked by the drill presses and automatic lathes. We're proud of this equipment but you've probably seen metal mutilated before, and it's our steam laboratory that's unique. We promise you a good show, and if you have any problems, bring them along. We'll solve them while you wait.

ANYONE FOR KEY CHAINS?

We seem to have these key chains. Want one? They're much more convenient than a case. A tiny replica of a Sarco Thermo-Dynamic Steam Trap, Type TD-50 is attached, but you can always remove it if you find it too commercial. There must be many things you could use these chains for. Fishing sinkers? Lengthening a light cord, maybe? Anyway, if your Sarco representative is out, write in.

Pardon our monopolizing the conversation in this series of paid communiques, but we're trying our best to interest you in certain subjects that concern us both—to the point where you'll communicate.

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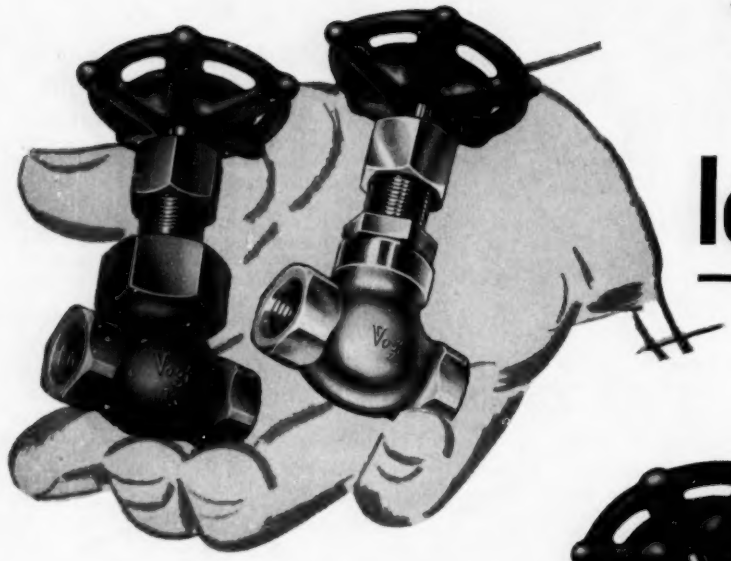

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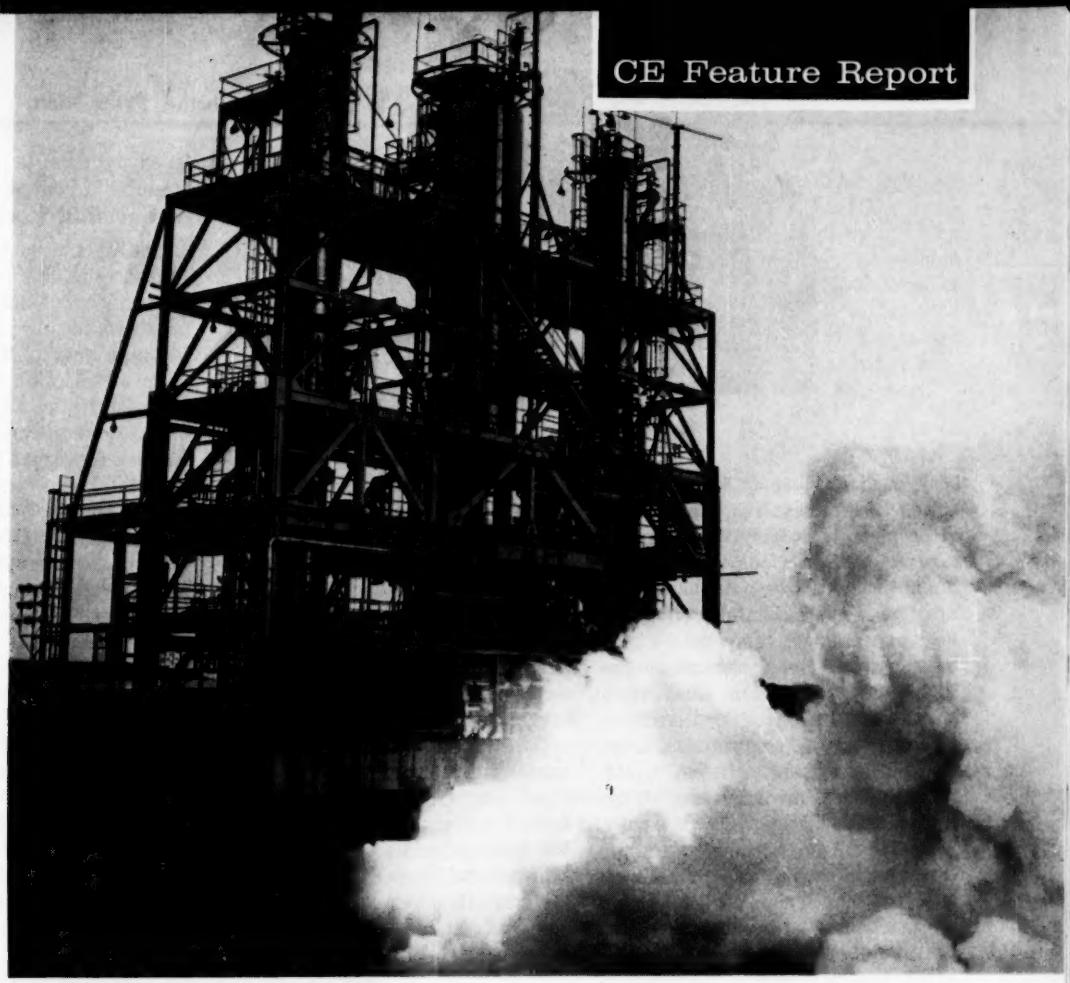


Liquid-rocket test stand—Aerojet General

Advanced Rocket Propulsion

Here is a discussion of actual, imminent and hoped-for advances in rocket propellants and engines – all part of the concerted effort to keep up in the space race.

FRANK J. HENDEL, *Project Manager, Aerojet-General Corp.*

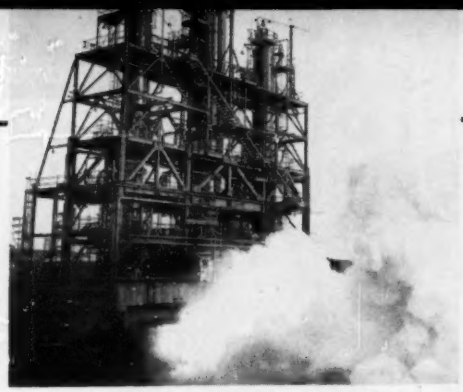
This is the second CE Report on the status of jet propulsion. The first, in the March 6 issue, gave the present status of the field. A future article will discuss the exotic rocket propellants.

Chemical propulsion is advancing both in propellant technology and hardware. Ingenuity in the selection of construction materials and hardware design, minimizing overall weight, results in higher net impulses just as definitely as does improvement of the actual propellants.

Advances in propellant technology include better and more powerful liquid propellants, both fuels and oxidizers; high-energy solid propellants; hybrid (liquid and solid) propellants. The story of chemical propellant development is told by F. Zwicky[44] in the following data:

1. The reaction C (amorphous) + O_2 (liquid) = CO_2 releases 2.08 kcal./g. of mixture (2.67 kcal./cc.).

2. The reaction $2H_2$ (liquid) + O_2 (liquid) = $2H_2O$ releases 3.60



kcal./g. of mixture (1.52 kcal./cc.).

Reaction 2 requires the storage of propellants at very low temperatures. Both reactions lead to triatomic gases, whose gamma ratios* are low, approximately equal to 1.30 at standard temperature and pressure and much lower at the high temperatures in combustion chambers. In practice, therefore, an unfortunate compromise must be struck, burning part of C to CO only, and not burning some of the hydrogen at all.

Searching for better propellants, the chemist begins with the difficulties just mentioned. The following five solutions suggest themselves for avoiding the carbon dilemma, which has its origin in the competition between the two oxides CO and CO_2 in combination with the water gas equilibrium $CO + H_2O = H_2 + CO_2$:

• Carbon may be dropped entirely and atoms such as Li, Be, B, Mg, Al, and Si substituted. If we compare the heat of combustion of B with that of C, we find values of CO, CO_2, and B_2O_3, to be respectively 26.84, 94.45, and about 300 kcal./g. mole, or 0.96, 2.16 and 4.30 kcal./g. of the original reagents (C or B plus O_2).

Free H_2 in the exhaust is most useful in achieving high gamma values. Hydrocarbons of the appropriate type $(CH_2)_n$ pack hydrogen in the weight ratio of only 0.17, while for B_2H_6 this ratio is much more favorable—0.28.

• Some C may be retained while introducing Li, Be, B, etc., as the main fuel constituents. Thus, we turn to the possibility of $C(BH_4)_4$ as one of the most attractive fuels. While it is as yet undecided whether this fuel can be made, other combinations of C, H, B, and perhaps N, can be achieved. Such compounds will provide fuels more powerful than the conventional hydrocarbons.

• If carbon must be retained, the difficulties may be overcome by eliminating its conventional associations with hydrogen, and with oxygen as the oxidizer. This leads to the startling observation that the condensation reaction of C (gaseous) into C (solid) liberates 15 kcal./g.—about four to ten times the heat of reaction available in conventional propellants.

It may thus be predicted that the use of "completely" amorphous carbon, or of "polymerized" C_n, will actually make available a good fraction of the enormous heat liberated in the condensation of carbon. For use in rockets, these reactions must be coupled with compounds liberating maximum amounts of gases.

• There is a possibility that powerful oxidizers may be developed. With the introduction of no-carbon fuels, the use of fluorine is naturally indicated.

• Significant improvements seem possible through the introduction of monopropellants (e.g., nitromethane). In the new field of fuels that do not contain carbon, a vigorous search for monopropellants appears particularly desirable.

Monopropellants fall into two classes. The first is made up of molecules that can, in principle, explode individually. These molecules are metastable—C_2H_2 is an example. The second type of monopropellant, such as nitromethane, is made up of molecules that, individually, are absolutely stable. A multitude of these molecules, however, can explode, thus constituting a thermodynamically pseudostable monomolecular gas, liquid or solid.

* Ratio of specific heats, c_p/c_v.

Impulse Limited in Chemical Rockets

Chemical propellants, which are heated by their own reaction, not externally, are limited not by temperature but by heat of reaction per unit weight. Table I shows the heat of reaction for high-energy propellants for the stable state at ordinary temperatures.

With the usual fraction of 50 to 60% total heat content converted to kinetic energy, even the most energetic of propellants—beryllium and fluorine, to form BeF_2—give a specific impulse* of not over 500 sec. Combustion temperature would be of the order of 5,000 K. (8,000 F.), even allowing for dissociation effects. This temperature is beyond the capabilities of present nozzle-cooling systems, especially since neither of the propellants could be used for cooling.

Although the specific impulses of the advanced propellants are better than those of the presently used combinations, even the best high-energy propellants imaginable have limitations. Thus, there will never be chemical rockets with specific impulses over 500 lbf.-sec./lbm.

In the field of ducted propulsion devices, where one of the propellants is ducted into the device from the external fluid (air for the air breathing engines and water for underwater devices), the chemical (propellant) carried aboard the device may exhibit specific impulse even up to 1,200 lbf.-sec./lbm.

A combination of chemical and nuclear rockets can reach perhaps a specific impulse of 800 lbf.-sec./lbm. This type of combination is called "nuclear hybrid propulsion."

Free-radical jet propulsion is a special type of chemical propulsion in which metastable free radicals (of certain chemical elements or compounds) combine with each other and release enormous heat energies. Specific impulses of free radicals might reach 2,000 sec. Although a great amount of re-

* Specific impulse I_s shows the efficiency of a propulsion system. It is defined as $I_s = F/w$, where F is the thrust developed in lb. force and w is the amount of propellant consumed per second in lb. mass. Thus, units of I_s are lbf.-sec./lbm. I_s is also expressed as sec., from $I_s = C/g$, where C is effective exhaust velocity in ft./sec. and g is ft./sec.^{2}

search on the free-radical jet propulsion has been carried out already, this type of propulsion is now considered hopeless.

Recombination ramjet, also called interplanetary aeroduct, is a conceptual ducted-propulsion system that could be used in the upper earth atmosphere (or perhaps within the gases surrounding other planets). This type of propulsion does not carry any propellants aboard the device, but relies on ducting rarified atomic or ionic oxygen, nitrogen or hydrogen existing in the upper atmosphere, into the device, and combining them into molecules of the corresponding elements. The released heat energy would heat the now-compressed gases and, by ejecting them through nozzles, propulsion would be achieved. This type of propulsion is still poorly understood and no experience or test data are available. It is felt that experience on free radicals will help here.

Advanced Liquid Rockets

Refs. 2, 7, 10, 12, 16, 25, 36, 41, 47, 48, 51, 52, 59

Considerable research and development is being carried out in handling and utilization of powerful and/or storable liquid oxidizers, fuels and monopropellants.

In the field of cryogenics[51] great strides are being made with liquid hydrogen (LH_2, b.p. — 422 F.) as fuel, and liquid fluorine (LF_2, b.p. — 306 F.) as oxidizer. Relatively less work is being performed with other cryogenic propellants such as liquid ozone (LO_3, b.p. — 169 F.), nitrogen trifluoride (NF_3 b.p. — 207 F.), oxygen difluoride (OF_2 b.p. — 228.6 F.) and other fluorinated compounds of nitrogen (see below) as oxidizers; and liquid acetylene (C_2H_2, b.p. — 119 F.), liquid ethylene (C_2H_4, b.p. — 155 F.), liquid methane (CH_4, b.p. — 258 F.) and boron hydride (B_2H_6, b.p. — 126 F.) as fuels. Perchloryl fluoride (ClO_3F, b.p. — 52.2 F.), a good oxidizer, is today considered a storable propellant; its critical temperature is over 200 F. and hence, when kept in pressure tanks at atmospheric temperatures, it is in liquid phase.*

Hydrogen[12] has long been recognized as a rocket fuel with outstanding thermodynamic performance characteristics. Its high heat of reaction with all oxidizers, combined with low average molecular weight of the reaction products, produces specific impulses higher than chemical systems employing any other fuels. In addition, the high diffusivity and chemical reactivity of hydrogen and its high cooling capacity simplify problems of injector and thrust-chamber design. Because the element has some less favorable characteristics, such as low boiling point and low density (0.58 lb./gal.), the payload capability of actual vehicles employing this fuel must be studied to evaluate its true worth.

Fig. 1 shows the high theoretical specific impulses obtainable for the hydrogen-oxygen combination. The values were calculated" for 300 psia. chamber pressure exhausted to vacuum. The longer the nozzle, i.e., the higher the nozzle area ratio (exit area/throat area, also called expansion ratio), the higher the performance. (Compare these values with 391 lbf.-sec./lbm. for 1,000 psia./14.7 psia., Table III, first article).

* On the same basis, liquid ammonia (NH_3 b.p.—28 F.) is considered a storable propellant.

Liquid Hydrogen Boosts Payload

Perhaps the most immediate application of liquid hydrogen is in top stages on existing boosters to improve the space payload capability. For example, when a third stage is placed on an assumed conventional two-stage vehicle, with resulting stage-weight ratios of about three, the use of hydrogen in the third stage increases the payload delivered to a 300-mi. orbit by 10% over that obtained with conventional propellants. However, the hydrogen third stage delivers to a 24-hr. orbit* twice the payload afforded by conventional propellants. This emphasizes the payload gains possible for difficult missions by using high-energy propellants.

The fact that hydrogen upper stages can significantly increase the payload placed in orbit by existing boosters has been recognized by the National Aeronautics and Space Administration in planning its space vehicle program. In its space research, NASA plans to use hydrogen-fueled Centaur stages on the Atlas to boost a payload weighing more than 1,500 lb. into 24-hr. orbit. Only 750 lb. of payload could be boosted into the same orbit by a conventionally fueled stage on the same booster.

In view of the payload advantages obtained with hydrogen, and considering its excellent combustibility, it is really remarkable that it was not used in the earliest rocket experiments. The late entry of hydrogen into practical rocketry probably can be ascribed to concern over handling it as a liquid.

A regeneratively cooled thrust chamber is necessary to obtain a significant degree of superiority with hydrogen over noncryogenic propellants. The remarkable heat capacity of hydrogen makes regenerative cooling a practical proposition. Of the two regeneratively cooled engines, the turbopump system provides a clear-cut margin of payload superiority. Several years' experience in the development of liquid-hydrogen pumps has shown that a turbopump system can be developed without sacrificing reliability. It is of interest to note that the turbopump and regenerative-cooling experience gained through the use of oxygen-

* A "24-hr. satellite" will be a satellite orbiting the earth at 24 hr./revolution. Thus, the satellite will appear, from the proper point on earth, to be suspended motionless above that point. Taking under consideration that the satellite period of revolution increases with altitude, the "24-hr. satellite" will have to be approximately 20,000 mi. above the earth.

hydrogen engines is directly applicable to hydrogen-propellant nuclear rocket technology.

Fluorine[23] is the most promising high-energy oxidizer for immediate application. It can be used with relatively small proportions of hydrogen to give theoretical specific impulses of between 450 and 500 sec. The reactivity of fluorine is well known; it will even burn water. An igniter is never needed when fluorine meets fuel.

Fluorine, however, attacks most organic and inorganic substances to a certain degree. Fortunately, its attack on metals that are useful in missiles is slow enough to rate them acceptable. Aluminum, copper, brass, stainless steel, Monel and nickel are satisfactory with fluorine up to room temperature and perhaps higher. Fluorine attacks these metals and forms a fluoride film that slows further reaction. A common practice in fluorine-handling systems is to "pickle" the system after cleaning, by using low-pressure fluorine gas to form a protective coating.

There are no suitable elastomers for use with fluorine. Teflon, the most resistant one known, fully disappears in a stream of fluorine. Fluorine systems must be kept scrupulously clean of contaminants, and must have as few seals as possible, no crevices and no porous metals. Metallic seals and welds are X-rayed to assure against cracks, slag inclusions and other impurities.

For many years, fluorine was considered to have a low specific gravity until an alert experimenter at Aerojet-General had trouble with flowmeter calibrations and unearthed a basic error in previous measurements. The specific gravity of fluorine was found to be 1.513 g./cc. at −188.13 C., or about 94 lb./cu. ft.

Fluorine is very toxic—tenfold more so than its exhaust product, hydrogen fluoride. Fortunately, the human nose is a very sensitive indicator of minute concentrations of fluorine or hydrogen fluoride, though not an infallible one. Persons with respiratory troubles are particularly vulnerable, and anyone exposed to fluorine should have periodic clinical checkups.

Fluorine Presents Handling Problem

There may be times in an experimental setup or at a launching site when fluorine must be disposed of. Burning with a hydrocarbon or reacting with steam has been used in disposing of small quantities. A convenient disposal system consists of drums containing picnic charcoal. The fluorine reacts spontaneously with the charcoal to provide harmless carbon fluorides. Water is also a handy safety means because it can react with fluorine to produce hydrogen fluoride, which can be absorbed by more water and neutralized by calcium hydroxide.

Encasing fluorine systems with liquid nitrogen is another safety precaution, and is used in transporting liquid fluorine. The transportation problem has been solved by use of mobile tanks comprising a central container maintained below the boiling point of liquid fluorine by a jacket of liquid nitrogen, and the whole surrounded by vacuum insulation. Such a container permits ground storage of liquid fluorine at economies comparable with those for storing liquid oxygen, and has been shown reliable for cross-country movements.

A great problem at an experimental laboratory or a launching site is to deal with large quantities of spilled fluorine resulting from a system failure.

Hydrogen fluoride in the rocket exhaust also presents a problem but can be handled by enclosures and water absorption.

Combustion temperatures with liquid fluorine are much higher than with oxygen, so an already troublesome problem of rocket engine cooling is worsened.

This doesn't mean that liquid fluorine never will be used with liquid hydrogen (super-high-energy bipropellants), or that the added 19 sec. of performance is insignificant. But we can say the oxygen-hydrogen propellant combination offers enough promise for meeting the high-energy needs of far space missions so that the future of LOX for rockets is almost guaranteed.

Ozone[35] gives a higher performance with hydrogen (super-high-energy bipropellants) than other oxidizers, but its superiority over fluorine comes only at the price of using a much greater proportion of hydrogen in the combustion process. The drawback of ozone is its thermal instability and the literature has many particulars about its bad behavior, although researchers now attribute much of this reputation to the presence of impurities.

Ozone concentrations of up to 30% by weight in oxygen are considered usable, but extreme care must be taken to have contaminant-free systems and to prevent an increase in ozone concentrations through oxygen boil-off. These formidable problems make this oxidizer less attractive than fluorine at present and offer a great challenge to the research chemist.

Oxygen bifluoride[22] is somewhat less interesting than fluorine. It is as toxic as fluorine, harder to make and, as one would suspect, lies between oxygen and fluorine in performance. The handling and materials problems with oxygen bifluoride may be simpler than for fluorine but this has not been established. At liquid-nitrogen temperature, oxygen bifluoride has a density of 111 lb./cu. ft. as compared with 97 lb./cu. ft. for fluorine. This advantage disappears if both are used at their boiling points.

The oxygen content is helpful when carbon-contain-

Heats of reaction—Table I

Compound	Kcal./G.	Compound	Kcal./G
HF	3.21	MgF_2	4.23
H_2O	3.31	B_2O_3	4.33
MgO	3.57	Li_2O	4.77
AlF_3	3.70	BeF_2	4.83
BF_3	3.91	LiF	5.64
Al_2O_3	3.91	BeO	5.84

Properties of cryogenic propellants—Table II

Propellant	Boiling Point (°F.)	Critical Pressure (Atm.)	Critical Temperature (°F.)	Density at Boiling Point, (Lb./Cu. Ft.)	Stability	Reactivity	Acceptable Materials	Toxicity for 15-Min. Exposure
Liquid oxygen	−297.4	49.7	−182	71.26	Very good	Nonhypergolic at ambient conditions	Nickel, monel, inconel, copper, aluminum, stainless steel, Kel-F, Teflon*	None
Liquid fluorine	−306	55	−200.5	94.5	Very good	Hypergolic with fuels and organic compounds at low temperatures	Monel, nickel, copper, aluminum, stainless steel (300 series) brass, and if fully dry, steel	Extremely dangerous above 25–50 ppm., lung damage above 15–25 ppm., tolerable 0.1 ppm. (continuous)
Liquid ozone	−169	54.6	10.2	91	(0–20% O_3 in O_2) fair to good, above 20% explosive	Hypergolic with some materials†	Stainless steel (302, 304, 316, 410, 416), Al (25, 35, 24S, 525, 615), Kel-F, Teflon	Intolerable above 5 ppm., tolerable 0.1 ppm. (continuous)
Oxygen difluoride	−228.6	48.9	−72.3	95.0	Very good	Same as F_2	Same as F_2	Same as F_2
Liquid hydrogen	−422	12.77	−400.3	4.43	Very good	Air 4.1 to 74.2 by volume, O_2 4.6 to 93.9 by volume, hypergolic with F_2	Monel, nickel, Inconel, 18–8 stainless steel, low-carbon steels	—
Nitrogen trifluoride	−207	—	—	96	Good			

* Most commercial materials suitable for temperature and pressure conditions may be considered.
† Alpha-pinene, UDMH, unsaturated hydrocarbons.

ing fuels are considered. Since the cost of oxygen difluoride will probably not be less than that of liquid fluorine, it is not yet clear in which situations the compound would be advantageous.

Nitrogen trifluoride,[22] as distinct from nitrogen trichloride, is a stable, inert, noncorrosive gas that requires low temperature liquefaction and storage. Good specific impulse can be calculated for this compound, but not much advantage over liquid oxygen is evident.

In addition, nitrogen oxyfluoride NOF (b.p. — 69 F.), nitroxyl fluoride NO_2F (b.p. — 82 F.), difluorodiazine N_2F_2 (b.p. — 170 F.) and the recently discovered tetrafluorohydrazine N_2F_4 (b.p. — 100 F.) are all of interest as oxidizers.

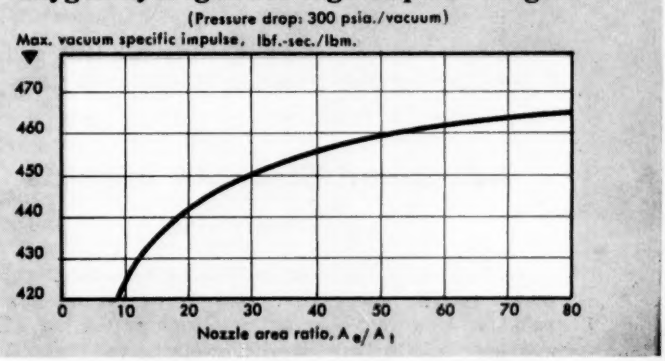
Comparison of advanced cryogenic propellants with liquid oxygen is given in Table II.

High-energy bipropellant combinations are classified by Y. C. Lee[41] into three groups:

1. High-energy bipropellants, e.g.,
   Liquid oxygen—JP-4*
   Liquid oxygen—alcohol
   Hydrazine—chlorine trifluoride
2. Very-high-energy bipropellants, e.g.,
   Liquid oxygen and fluorine—JP-4
   Liquid oxygen and ozone—JP-4
   Liquid oxygen—hydrazine
3. Super-high-energy liquid propellants, e.g.,
   Fluorine—hydrogen
   Fluorine—ammonia
   Ozone—hydrogen
   Fluorine—diborane

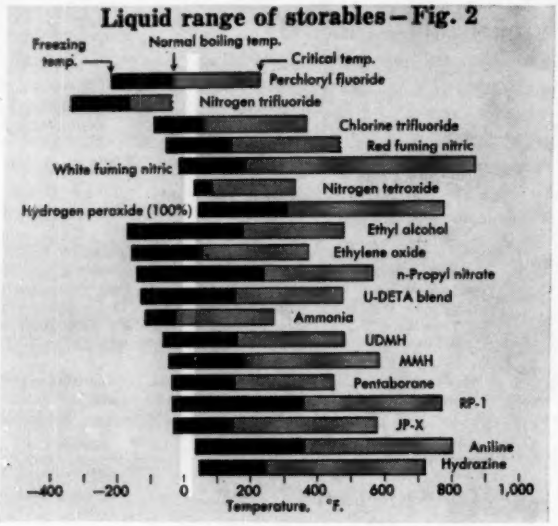
*JP-4 is a petroleum hydrocarbon jet fuel similar to kerosene or RP-1 fuel. 90% distills at 470 F.

Oxygen-hydrogen for high impulse – Fig. 1



Research and development continue not only in the second and third group, but also in the first.

For instance, studies were made at Temple University Research Institute in Elverson, Pa.[1], on high energy propulsion with cyanogen C_2N_2 (b.p. — 6 F.)



and hydrogen cyanide HCN (b.p. 78 F.) as fuels, and LOX mixed with liquid fluorine, and liquid fluorine, as oxidizers. Chamber temperatures were between 4,400 K. and 4,950 K. The combustion problems with cyanogen apparently resulted from the breakdown of this highly exothermic fuel into its elements before dissociation could take place. The reaction

$$(CN)_2 \rightarrow 2C + N_2 + 73 \text{ kcal.}$$

occurred instead of the reaction

$$(CN)_2 \rightarrow 2(CN)$$

The high densities of fluorine, $(CN)_2$ and HCN still hold out the important possibility of lower mass ratios.

Advanced Storable Liquids

Refs. 7, 9, 21, 31, 39, 40, 57

Early storable* liquid propellants were characterized by low specific impulse, compared with cryogenic propellants. However, a major drawback to the use of cryogenic liquids is the need for venting the tanks to permit the propellants to boil off until the instant of firing. Because of this, the engines cannot be stored in the loaded condition, and substantial preparation time is required to load the tanks and to top them off before launching. The low density of cryogenic propellants is another drawback. Moreover, substantial difficulties have been encountered with ignition and combustion stability.

The advanced storable liquid propellants have high specific impulses and avoid the drawbacks of cryogenic propellants. To the advanced storables[7] belong pentaborane, monomethylhydrazine (MMH) and mixed amines as fuels, and chlorine trifluoride, perchloryl fluoride and bromine pentafluoride as oxidizers. Fig. 2 shows liquid range of conventional and advanced storable propellants.[7]

Pentaborane—The greatest stir in the rocket industry is being caused by pentaborane (B_5H_9). Theoretical calculations, as well as small-scale testing, indicate exceedingly high specific-impulse values for some pentaborane-oxidizer combinations. For example, the calculated performance of 95% H_2O_2 and pentaborane is 312-15 sec. (1,000 psia./14.7 psia.), compared with 300 sec. for the conventional LOX-hydrocarbon combination.

A new concept in liquid-propellant systems has evolved from consideration of two families of compounds as boron nitride sources in rocket exhaust products. Boron nitride's theoretical high heat of formation makes increased rocket-engine performance feasible through the use of boron and nitrogen compounds that yield hydrogen as a working gas in the combustion products, thus reducing the average molecular weight of exhaust gases.

The two families of compounds, boron hydrides and nitrogen "hydrides" (ammonia, hydrazine, and hydrazine derivatives) are ordinarily regarded as fuels. In the new concept, however, the boron hydrides behave as fuels, and the nitrogen "hydrides" behave as oxidizers.

Theoretical specific-impulse values calculated for various propellants of these types range from 270 to 347 sec. In those propellant systems containing carbon, sufficient oxygen is included in the oxidizer to cause combustion completely into carbon monoxide.

Another interesting system is the use of pentaborane or other boron hydrides with mixtures of ClF_3 and ClO_3F. It is postulated that BOF, a gas, is formed in the combustion process. The high theoretical specific impulse and relatively high bulk density of this system warrant further investigation.

Monomethylhydrazine (MMH)—MMH remains liquid over a wide temperature range and has other properties also favorable to long-term storage in prepackaged systems. However, because interest in MMH as a rocket fuel is quite recent, its cost is relatively high and it is available only in limited quantities.

New manufacturing processes are expected to increase production and decrease cost in the near future. The performance of MMH, which is intermediate between UDMH and hydrazine, has been demonstrated in a number of full-scale tests. Unlike hydrazine, MMH does not detonate (a problem encountered in vapor-phase decomposition of hydrazine).

Mixed Amines—Mixtures of amine-type fuels have performance, density or physical properties that are not obtainable with the unmixed fuels. Experience with mixtures of hydrazine with UDMH and with MMH has shown that the vapor-phase problems of hydrazine are eliminated and that the performance is intermediate between those of the components of the

* Storables are also called "canned" liquid propellants or prepackaged liquid rockets.

mixtures. Some depression of the freezing point of hydrazine is also obtained with these binary mixtures, (Aerozine, a mix of hydrazine and UDMH,F.p. = 18 F.) but ternary mixtures must have a freezing point at or near −65 F. "Hydrazoid" fuel is such a ternary mixture. Only small-scale tests have been made with this fuel.

Increased density can also be obtained by using mixtures of UDMH and diethylenetriamine (DETA). Although this two-component system does not give density values as high as for the hydrazoid fuel, full-scale tests have proved the UDMH-DETA mixtures practical for current use. Viscosity data indicate that mixtures containing as much as 60% DETA are practical down to temperatures as low as −40 F.

Chlorine Trifluoride (ClF_3)—This is a storable oxidizer that can be used in prepackaged propulsion systems. Its primary advantage is the large increase in bulk density and density impulse. The bulk density of the ClF_3/N_2H_4 system is almost 25% above that of N_2O_4/UDMH, although the specific impulses of these two systems are almost identical.

A number of metals, including stainless steel and aluminum, are compatible with ClF_3, due to the formation of passive fluoride films. Consequently, handling problems are not a serious obstacle to its use, and availability and cost will improve as production rises. Many full-scale tests have been conducted.

Perchloryl Fluoride (ClO_3F)—When ClF_3 is used with carbon-containing fuels such as UDMH or MMH, an oxygen-containing oxidizer should be mixed with the ClF_3 to allow the formation of CO and CO_2, rather than the fluorides of carbon.

Perchloryl fluoride can be added to ClF_3 for this purpose. ClF_3 containing less than about 40% ClO_3F drops sharply in performance when used with UDMH. Because of its high vapor pressure and high coefficient of expansion, perchloryl fluoride is not a practical storable propellant by itself. When mixed with ClF_3, its properties, except for vapor pressure, are essentially masked by the ClF_3. Tests with a number of storable liquid fuels have been conducted.

Bromine Pentafluoride (BrF_5)—Bromine pentafluoride, liquid over a wide temperature range, is even more dense than ClF_3. Because of its high density impulse, it can theoretically provide a significant improvement in mission capability for some volume-limited applications. BrF_5 is a storable material that can be used in prepackaged systems and has handling properties similar to ClF_3. Theoretical calculations show BrF_5/B_5H_9 to be a high-performance system.

Other exotic storable propellants under investigation are lithium metal, lithium borohydride, aluminum borohydride, and aluminum hydride as fuels, with exotic or even conventional oxidizers. Table III shows their performance.

The combination of nitrogen tetroxide and lithium borohydride is an unusual example. Both materials are potentially available in commercial quantities at low cost. Preliminary estimates indicate that specific impulses of 290 to 300 sec. should be attainable with this combination at sea-level conditions. Even though $LiBH_4$ is not a liquid, it could be slurried with a liquid.

Another noteworthy combination is IRFNA* and lithium. It is calculated that these propellants will attain high-altitude specific impulses in excess of 300 sec. Lithium is a solid at ordinary temperatures and requires heating to the relatively low temperature of 356 F. to operate in a liquid engine.

In systems where volume limitations are a major design factor, the density of propellants is quite important, even at the expense of some loss in impulse. A very promising propellant combination in this category is aluminum borohydride and bromine pentafluoride, having a density specific impulse of 450 sec.

* UDMH is unsymmetrical dimethyl hydrazine.

Typical high-performance storable propellants—Table III

System	I_s* Exhaust to 14.7 Psia.	I_s* Exhaust to Vacuum (Est.)
IRFNA-Li	298	400
IRFNA-$LiBH_4$	286	380
N_2O_4-$LiBH_4$	292	390
ClF_3-$Al(BH_4)_3$	266	355

* Combustion-chamber pressure of 300 psi.

Liquid-Rocket Hardware

Refs. 8, 41, 53, 54, 55

Advanced propellant-flow valves give close control of propellant-mixture ratio, pump speed and torque, and insure efficient combustion. These proportioning and ratio valves are connected through a servo loop to a sensor registering the chamber pressure, which gives a good indication of the combustion and thrust.

By installing baffles and grids in the tanks, propellant sloshing, which can cause serious perturbations in very large missiles, has been controlled.

Through the use of segmented injectors and special valves, smooth throttling operation has been made possible for liquid rockets.

Other important improvements being made are:

Plug Nozzles—By turning the conventional deLaval nozzle "inside out," we have the plug nozzle, which is simply a solid cone that is pointed in the direction of the rocket exhaust and whose base is slightly smaller than that of the vehicle. Around this base is arranged a ring of small combustion chambers of conventional design. The exhaust flames from these combustors are directed inwards onto the wall of the plug-nozzle cone and flow along it.

The great advantage of the plug nozzle is that it is relatively simple to increase an engine's thrust by increasing the number of small combustors around the nozzle's base. With a conventional nozzle, an

* IRFNA is inhibited red fuming nitric acid.

entirely new configuration would have to be developed. Thrust vectoring is also made easier by a simple control of the propellant flow to some of the combustors.

K. Berman[5] shows that the plug-nozzle engine gives a much greater compactness than the conventional engine. In one case, he indicates that a 19-ft.-long conventional liquid engine can be replaced by an 8-ft.-long plug-nozzle engine.

Girder Structures—So long as propellant tanks are part of the vehicle structure, they will have to be pressurized and therefore be made of expensive, hard to work materials. Furthermore, as tank sizes increase, these problems, as well as others of structural design and handling, become much worse. Designers, therefore, are working on vehicles whose external structure consists of aluminum girders. Tanks supported by such structures could be made of cheap, low-strength metals or even plastics, because they would not have to be highly stressed.

Bladder Pressurization for Liquids—In this design, the pressurizing gas is not pumped directly into the propellant tank (to press down on the propellant from above) but rather into a bladder hung inside the tank. As the gas inflates the bladder, outward pressure is exerted on the propellant from all directions. Such an arrangement is essential for space flight under free-fall conditions, when the gas may not remain above the propellant in conventionally pressurized tanks.

Stage Separation—In a multistage rocket, this has always been a problem. Separation is normally achieved by explosive bolts, primacord, or by mechanical latches triggered by an explosive bolt or squib. Exploding primacord rips the metal. The pressure wave it produces and/or the flying metal fragments may damage sensitive parts within the interstage compartment, such as the rocket nozzle of the upper stage. Shaped charges, on the other hand, leave a clean cut in the metal and cause little fragmentation. Finally, explosive bolts have become more reliable and offer a fast and simple way of separating two sections.

Further improvements are:

1. To ensure start of smooth combustion at high altitudes (vacuum), the nozzle throats of the upper stages have a sealing plug. Thus, the combustion starts at sea level pressure.

2. Blast doors often are used in the transition section when an upper stage must be fired immediately after shutdown of the lower stage. As the flame of the upper-stage engine sprays out of the holes left by the blast doors, harmful pressure build-up is avoided. In such instances, the propellant-tank dome of the lower stage is protected against a blast-through when the engine of the separating upper stage is ignited.

3. Explosive bolts used for stage separation usually are hollow aluminum containers that can be screwed or riveted into the structure and may have a load-carrying function. They may use dual ignition squibs and a single charge.

4. In "flower petal" separation, metal petals open up as the upper stage fires. The petals normally are load-carrying members. They should be hinged and held together by a hoop that in turn is split and held by an explosive bolt. Split joint is an alternative design.

5. Clustering of large liquid boosters (as in the Saturn) shortens the development program.

6. Extremely low chamber pressures (possible for liquid rockets only) for the upper stages are now being investigated. High performance can be obtained with reduced inert weights, reduced pressurization-gas requirements, smaller gas generator needs, and long operation, because of greatly reduced heat-transfer rates to chamber and nozzle walls. Combustion studies have indicated that a chamber pressure of 5 psia. is feasible, with resulting high performance and low heat-transfer rates.

Low chamber pressure also permits the use of a simple gas-pressurization system instead of a turbopump system. In the case of some propellants, the force of vapor pressure can be used, with the addition of heat, to supply the needed pressurizing gases.

The potentialities of the prepackaged, low-chamber-pressure liquid rocket are enormous, particularly for the upper stages of a space vehicle.

New Techniques for Testing Liquid Propellants

A small-scale thrust chamber, which has proved quite effective for propellant evaluation at Aerojet-General, has been described by J. A. Bottorff.[6] It is the "100-lb.-thrust, transparent chamber" of a 100-lb. nominal thrust-level. This chamber has been extensively used for preliminary evaluation of basic injector patterns. A number of propellant combinations, including new storable and cryogenic propellants, have been satisfactorily tested in these chambers.

Two parallel sides of the chamber contain replaceable windows, through which photographic studies of the ignition and combustion processes can be made. Plexiglas windows are normally used for short-duration tests with propellants that produce relatively inert exhaust gases. For more-reactive exhaust species, such as produced by the fluoride-containing oxidizers, a material such as Vycor may be used, either as a window itself or as an inner liner in conjunction with Plexiglas. The design of the chamber permits simple removal and rework of the injector elements.

After preliminary experimental data have been obtained, and adequate handling techniques have been developed, with the 100-lb.-thrust transparent chamber, an experimental evaluation at a higher thrust level is desirable. This thrust level should be high enough so that reliable thrust data and good thrust-chamber and heat-transfer measurements can be made. The thrust range of 5,000-10,000 lb. in a normal captive (static) firing is usually adequate for this. The next step would be a static firing of a full-scale engine (e.g. 130,000-lb. thrust). However, there is an advantage in using a new thrust-chamber concept that involves a wedge-shaped chamber (having a transparent side) that simulates full-scale captive firing.

The wedge thrust chamber evolved from the need

for a suitable laboratory tool to assist in the development of large thrust chambers. The design of the wedge chamber is based on the premise that, during stable combustion in a thrust chamber, there is negligible circular movement of mass or energy. Therefore, a radial separator, placed perpendicular to the plane of the injector face, will not materially affect the combustion process in the wedge section. The resulting configuration represents a segment of the complete thrust chamber and thus permits testing at a reduced thrust level.

This approach offers many advantages in the development phases of a program. Considerable savings in development costs should result from the lower manpower complement and relatively inexpensive hardware. The wedge thrust chamber allows most of the design concepts that are to be incorporated in the full-size engine to be established rapidly and economically in small-scale tests. A wedge chamber having a wedge angle of 27° represents approximately one-thirteenth of a full-scale thrust chamber. Consequently, this chamber, operating at a thrust of 10,000 lb. would simulate a full-scale chamber rated at about 130,000 lb. of thrust.

Concurrent with the evaluation of combustion performance, combustion-stability information must be obtained. This study must be integrated closely with the performance evaluation because, in many cases, injector patterns that provide high combustion efficiency also have inherent design characteristics that result in unstable combustion and thus cannot be adapted to a full-scale thrust chamber.

Pulse Motor Evaluates Combustion Stability

The evaluation of the combustion-stability characteristics of a particular injector design in a full-scale thrust chamber can be an expensive and time-consuming undertaking. A new technique that permits inexpensive evaluation of combustion instability involves the use of the pulse motor.

The pulse motor is used to evaluate the resistance of a selected injector pattern to tangential combustion instability. The pulse motor consists of an uncooled chamber that simulates the proposed full-scale thrust chamber with respect to diameter, length, and contours of the injector face and the chamber converging section. The most significant difference between the pulse motor and the full-scale motor is that the propellant is injected into the pulse motor through a series of removable injector elements around the periphery of the injector and not over its entire face. Thus, injection takes place in the outer annulus of the injector face, which has been shown by experience to be the location of the shock front comprising tangential instability.

These injector elements typically contain about 10% of the orifices of the full-scale pattern and, therefore, pulse-motor propellant-flow rates are about 10% of those of the full-scale chamber. To maintain full-scale chamber pressure, the throat area is varied by replaceable nozzles with the desired throat area. The small injector elements are readily removable and are designed to facilitate the rapid, economical testing of several injector-pattern modifications.

When steady-state operating conditions have been established in the pulse motor, a series of five pulse generators are used to produce five successive pulses, each of increasing intensity, in the chamber. These pulses enter tangentially, to excite most effectively the tangential mode of instability. The strength of the pulse required to induce instability is, therefore, a measure of the resistance to instability of the particular injector pattern being tested. An automatic device stops the test if instability starts, assuring that hardware damage will not occur.

During the six years that pulse motors have been in use at Aerojet, they have been developed in various sizes ranging from 15 to 72 in. in diameter and simulating full-scale thrust chambers with nominal thrust levels ranging from 125,000 to 3,000,000 lb.

Full-scale static testing of high-thrust liquid rocket engines requires extensive and complex test stands and supporting equipment. Tennenbaum and Sprattling [57, 58] have described Aerojets facilities for testing giant rocket engines. These stands resemble large outdoor installations of a chemical plant or petroleum refinery—afire. A single control building, heavily protected by reinforced concrete and ballast, directs several stands. Servicing several stands in each zone: a steel-building shop for maintaining test-stand equipment and checking out devices to be tested; an independent pressure source and supply system; a fuel supply and/or distribution system; flame deflectors; water supply and distribution systems; vacuum-insulated tanks for storing and distributing liquid oxygen, or similar equipment for handling other oxidizers. Rocket engines tested in the facility require equipment for handling large quantities of different liquid propellants.

Obviously, complex testing of this type requires something special in the way of instrumentation. The strain-gage system for measuring pressure, force and acceleration employs transducers with identical electrical characteristics and tightly controlled relations between electrical calibration steps and the parameter to be measured.

Turbine-type meters, which generate an a.c. output directly proportional to volumetric rate, form the basis for the main flow-measuring system. The a.c. signal from these meters is recorded directly, and converted to d.c. analog for display on direct-writing recorders. A thermocouple system with a 32 F. reference measures temperatures over the range −300 to 2,500 F.

Platinum resistance-thermometer bulbs are used to make very accurate measurements of materials at very low temperatures. And there is equipment for measuring rotational speeds, linear or angular position, electrical-control inputs and time intervals.

Recording measurements are made with chart markers, visual indicators, multichannel oscillographs, and a "Millisadic," which sequentially samples and digitalizes analog information at the rate of 400

samples/sec. for tape recording and subsequent processing onto punched cards for large digital computers.

Advanced Solid Rockets

Refs. 3, 6, 15, 19, 23, 24, 28, 49, 50, 61

Unlike the liquid propellant systems, which use commercially available "standard" chemicals, solid systems use mixtures and polymers of many chemicals. Because of the complexity of these mixtures, the solid grains are usually manufactured by large companies in the rocket industry. Although the chemistry and technology of advanced solid propellants are very involved, there are few publications available in the literature because most information is either classified or proprietary.

It is known, however, that within the last few years, the solid rockets have come a long way because of breakthroughs, especially in: higher impulse and higher density propellants; high propellant mass fractions yielding minimum weight and size; vector control and thrust termination; good physical and mechanical properties even at low and high temperatures; proper burning rates; low-weight combustion products; lack of resonant or unstable burning; and better manufacturing methods and equipment (continuous mixing plants).

With the advent of "cast-in-case" rockets, it was possible to reduce considerably the weight of the normally thick and heavy liner. The so-called "free standing" grain caused other problems that added to the rocket weight, i.e., how to suspend and trap the grain to prevent it moving about during handling and then jamming itself into the nozzle, causing rocket-case pressure to increase to the point of failure. With cast-in propellants, most rockets do not require mechanical resonance suppressors and associated supports, which have been quite heavy heretofore.

Better Materials of Construction

The International Nickel Co. indicates that a new stainless steel, available soon, will exhibit an ultimate tensile strength of 300,000 psi., corresponding to a strength-density ratio of 1.06×10^6. Titanium, on the other hand, shows promise as a new inert-parts material, but much more welding and forming experience is required. The poor high-temperature characteristics of titanium (over 800 F.) may yield problems that offset its advantages. A new series of low-alloy steels containing vanadium in conjunction with chromium, nickel and molybdenum will possibly also approach 300,000 psi. ultimate tensile strength.

Many rocket companies are conducting research and development of glass-fiber filament winding. Nozzles and expansion cones, which have previously been overdesigned and made of excessively thick steel, are an ideal application for glass-fiber or asbestos-reinforced resins that have a density of less than one fourth that of steel and can remain essentially intact when exposed to temperatures of 5,000 F. for 5 min.

All-Fiberglas nozzles, in addition to rocket chambers, have been developed and tested, utilizing Refrasil with very little erosion during fairly long burning times.

A serious limitation on present-day propellants is the lack of suitable materials for nozzles. Preliminary studies have indicated the feasibility of various methods of nozzle cooling. Some of the systems being studied involve secondary propellant charges, transpiration, film cooling and supplementary heat sinks. However, much concentrated effort must be applied before these studies can provide an efficient solution to the nozzle problem.

Chamber liners still are under constant scrutiny from an efficiency and reliability standpoint. Astrodyne reportedly has a rubber and asbestos liner that gives high protection from some of the present-day high-temperature propellants over a long burning time (in excess of 3 min.). However, the mechanical properties of the liner and its ability to bond to propellant and chamber must be constantly re-evaluated before new propellants can be used on production motors.

These advances make solids very attractive, especially in view of their commonly conceded advantages: high reliability under varied environmental conditions, minimum ground handling in preparation for launching, instantaneous readiness, minimum personnel for operations.

The past few years have seen the military services in almost every weapons category change requirements in missile propulsion systems from liquid- to solid-propellant rockets, as shown by the Air Force's Minuteman,[6] the Navy's Polaris[15] and the Army's Pershing. This growth of solid rocketry will continue, and it is expected that the specific impulse of solids will rise within a few years to 270 lbf-sec./lbm. (1,000 psia./14.7 psia.) using a combination of the elements O, H, N, F, C, Al, Mg, B and Be.

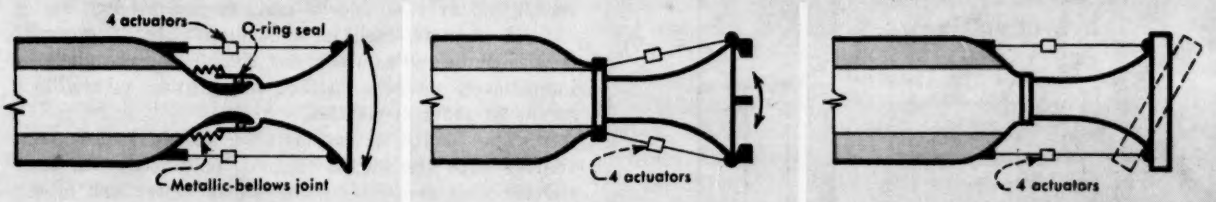
Cryogenic Solid Propellants to Come

Specific impulse for solid propellants may eventually be as high as 390 sec. This will be achieved with a cryogenic solid propellant produced by mixing solid oxygen (freezing point — 361 F.) and solid hydrogen (freezing point — 434 F.). It is known that liquid oxygen and liquid hydrogen are not hypergolic;* it is naturally anticipated that the lower temperatures will be even safer when mixing and keeping hydrogen and oxygen together. Perhaps even solid ozone, which is much denser than solid oxygen, could be mixed with solid hydrogen to produce even higher performance.

It is also tempting to seek the benefits of fluorine in solid oxidizers. The energy of the carbon-fluorine bond is so high that the usual fluorine polymeric compounds would have limited use. The nitrogen-fluorine bond appears to be less energetic, but no solid nitrogen-fluorine compounds have yet been reported. The

* Hypergolic describes a system where the fuel and oxidizer ignite spontaneously on contact, without auxiliary ignition.

Different designs for thrust-vector control of solid-propellant rockets – Fig. 3



Swivel nozzle | Jet vanes | Jetevator

highly endothermic oxygen–fluorine bond would be an energetic component, but most compounds with this bond are explosive, and no solid combination has been reported.

Farber[19] considers additional advantages of fluorocarbon binders in solid propellants; these are:

1. A fluorocarbon molecule acts as both oxidizer and fuel.
2. Since the molecular weight of fluorine is 19 times that of hydrogen, the relative percentage of carbon is reduced considerably. Also, the maximum performance obtained from carbon is approximately 1 kcal./gm. which is considerably lower than the average performance of the propellant.
3. Fluorocarbon materials have nearly twice the density of hydrocarbons.
4. Fluorocarbons are stable at considerably higher temperatures than the hydrocarbons.

There are available several castable fluorohydrocarbons having densities of nearly twice that of the conventional hydrocarbon binder materials. These high densities alone increase the velocity for small fixed-volume rockets approximately 15% above conventional propellants. The physical properties of these propellants are excellent. The fluorocarbon binders have generally excellent tensile strength and fairly good elasticity. They bond readily to smooth metals, plastics and glass. The monomers are clear, dense liquids that polymerize at fairly low curing temperatures upon the addition of suitable catalysts.

Fluorinated polymers have basically empirical formulas of the following type—(CH_xF,O_z). The polymers, as well as the hydrocarbons, require high percentages of oxidizing salts to form energetic propellants. The ideal binder would have sufficient fluorine and oxygen to eliminate the need for an oxidizing salt. The propellant would consist of binder and metal or metal hydride. Performance of this propellant would be increased considerably. The physical properties would be excellent since the binder would be more than half the propellant weight as compared with present propellants in which the binder is only a small fraction of the weight.

Scientists are attempting to incorporate oxidizing groups including NF_2, ClO_4, NO_2 and OF into the fluorocarbon molecule. The most desirable group would be OF, since both the oxygen and fluorine provide chemical enthalpy upon combustion. Although the nitrogen atom may lower the performance for vacuum flight, it may be necessary to include nitrogen to incorporate two fluorine or oxygen atoms, as in the NO_2 and NF_2 molecules.

The synthesis and polymerization of fluoro-olefins with the oxidizing groups discussed above are being investigated at the present. Fluoro-olefins under study include the perfluorocumulenes, tetrafluoroallene and perfluorobutatriene, the acetylenes, monofluoroacetylene, and 3,3,3-trifluoropropyne, perfluorobutadiene and the dimer of tetrafluoroallene. The sensitivity of oxidizing groups to molecules of this type is decreased by the stabilizing effect of the C-F bond, whereas the C-H bond (hydrocarbon binder) is readily oxidized by strong oxidizing groups.

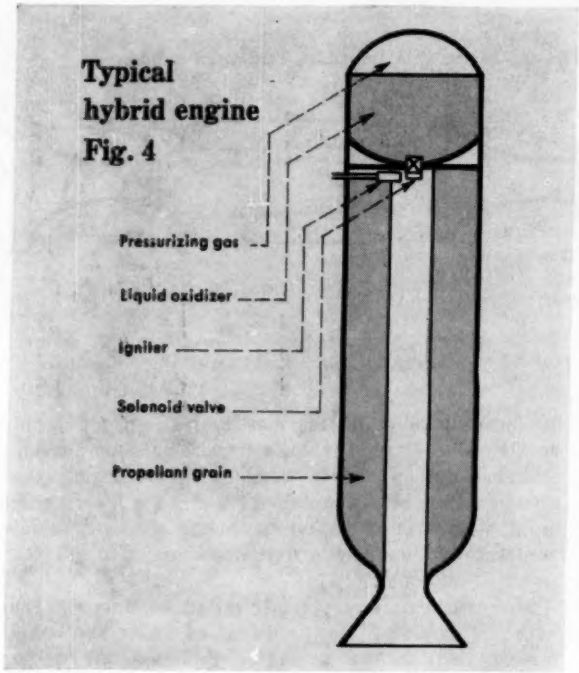
New Flight-Control Techniques for Solids

Present and future advances in solid rockets include thrust-vector control, thrust modulation, thrust cutoff, stage separation, clustering, spherical rocket and on-site loading of propellant into the rocket chamber.[3, 48, 49, 53, 64, 65]

Thrust-Vector Control—For such control, a swivel nozzle, small jet vanes, or a jetevator ring can be used (Fig. 3). In the case of the jet vanes—which can be made of carbon or some refractory or metal—four are needed for pitch, yaw and roll control. The jetevator ring has the advantage that it is exposed to the exhaust gases only when actually in operation. It therefore erodes more slowly than do jet vanes.

Thrust Modulation—Either an ultrasonic "whistle" or vent valves can be used to change or control the thrust level of a rocket. The sonic energy from the whistle is expected to affect the propellant burning rate by interaction with the hot reactant gases in the combustion chamber. The heat-resistant, hydraulically actuated vent or poppet valves would be used to vent some of the propulsion combustion gases directly from the thrust chamber rather than through the nozzle.

Thrust Cutoff—Large vents can be installed at either end of a combustion chamber. When the frang-



ible disks in these vents are explosively shattered, the chamber pressure quickly drops below the minimum value at which it can support combustion, and the rocket stops. If the vents are installed at the end of the chamber opposing the nozzle, both thrust and the forward force component are cut off within milliseconds.

Stage Separation—With solid-propellant rockets, staging and separation generally are much simpler. Since solid rockets have no plumbing and, as a rule, a simple ignition process, many electric or mechanical disconnects are unnecessary.

When very precise flight paths are required for multistage solid-rocket vehicles, a smoother separation scheme might have to be used to prevent an excessive load on the control mechanisms. However, these solid-rocket designs are still so relatively uncomplicated that some simple expedient such as slip joints and simple blast doors will prove adequate.

Stage separation in solid-rocket vehicles becomes more complicated when an upper stage is spun (as is the case with Vanguard's third stage), the spin counteracting thrust misalignments and insuring stability. The designer is faced with the extra problem of providing a mechanism that will both spin the rocket and release it when the lower stage slows down, so that the upper stage can sail freely on out of its "can."

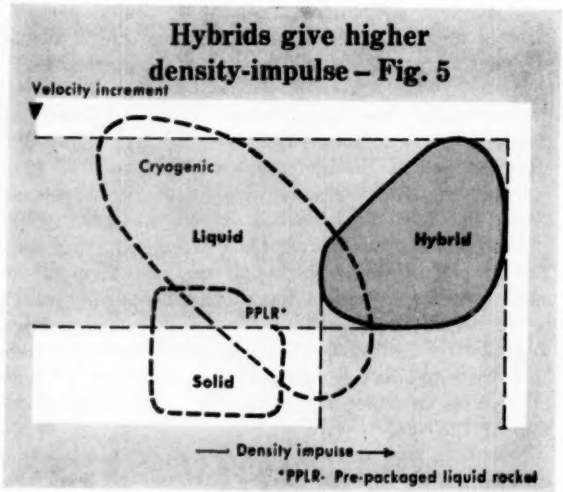
Clustering of Solid Rockets—Clustering (in parallel) of smaller solid rockets makes a high-thrust engine practical. Other advantages of clustering are:

- Failure of a single engine need not affect the vehicle's mission since the other engines in the cluster continue to operate. In this respect, a vehicle with a rocket cluster resembles a multi-engine aircraft.
- A cluster—even if it consists only of several nozzles connected to a common combustion chamber—immediately offers a method of attitude control by means of movable nozzles.
- The length of a clustered engine is 10-15% shorter than the single engine. This is due to the shorter (but canted) nozzles whose center line must pass through the vehicle's center of gravity (at start).
- For certain deep-space missions, clusters offer a means of thrust control with solid rockets, which so far has not been achieved in single units. All that is necessary is to fire the small solids of the cluster in succession.
- Most solids tend to produce small errors in thrust-vector alignment, which can be reduced if a cluster of engines pointing to a common center of gravity is used.

Naturally, clustering has its disadvantages: practically any cluster, except for the multiple-nozzle arrangement, imposes structural penalties, since extra elements must be provided to hold the units of the cluster together.

Clustering of Nozzles—A single combustion chamber can use a cluster of several short nozzles. In this case, there is no increase in total thrust from clustering. Rather, the advantages of this arrangement are that no separate, external units are needed for attitude control (since the multiple nozzles can be used for this purpose) and that the over-all vehicle is shorter than it would be with a single nozzle.

Spherical Solid Rockets—A spherical solid-propellant chamber is much shorter, lighter (because of the stresses) and occupies less room, than the conventional cylindrical chamber. The perforation in the spherical



propellant is quite tricky and difficult to manufacture.

On-Site Loading for Solids—Many handling problems of big boosters will be eliminated once solids are mixed and blended on site and fed into the rocket on the launch stand through pipes or hoppers. The curing of the propellant would take place within the rocket itself.

Rocket engines that incorporate all these improvements will meet the needs of many space missions, including advanced lunar flights and some planetary ones. These comparatively modest missions are all that we realistically can hope to tackle within the next 20 years. By the end of that time, chemical rockets will be powering tremendous vehicles with a thrust of several million pounds and will indeed have reached the limits of their potential.

Hybrid Rockets

Refs. 30, 33, 34, 46

Chemical hybrid (solid-liquid) rockets can be classified into three basic types: (1) a solid oxidizer grain and liquid fuel, (2) a solid grain containing a portion of the oxidizer, with the balance in the liquid phase, and (3) a solid-fuel grain with liquid oxidizer.

The first type presents a number of difficulties and limitations with currently available fuels and oxidizers but remains an interesting area for future development. The second represents a method of improving the physical properties of a composite solid propellant by reducing the oxidizer loading. At the same time, it takes advantage of the marked performance of a supplemental high-energy liquid oxidizer. The solid oxidizer can be reduced to a point where it is completely excluded. This leads to the third type, which is dependent upon the liquid oxidizer to sustain burning.

The storable hybrid rocket is a hybrid engine filled with (storable) liquid and solid propellants of long-term stability.

In general, the hybrid rocket provides greater flexibility in design, but with a slight sacrifice in simplicity when compared with a solid-fuel rocket. By reducing the solid-oxidizer loading, the hybrid eliminates many of the difficulties involved in preparing a high-performance grain that requires good physical properties over an extreme temperature range.

Vibration, shock sensitivity and thermal cycling are improved; propellant mixing is safer and easier. When all of the solid oxidizer is eliminated, grain manufacture takes less time and is less costly.

Hybrid Less Complex than Liquid Rocket

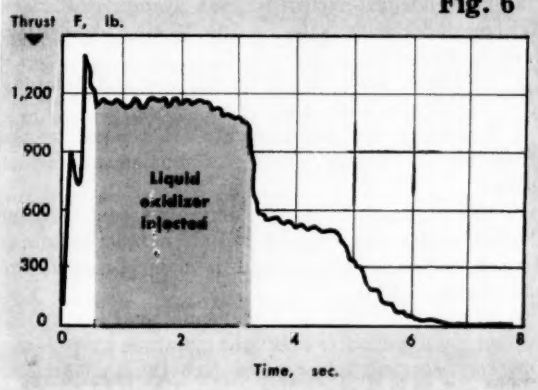
Compared with the bipropellant liquid rocket, the hybrid system provides at least the same degree of design freedom but with reduced system complexity and increased reliability. Development time and costs should be appreciably less, once the detailed characteristics of these hybrid systems become better known.

A hybrid system will permit the higher accelerations required for rapid maneuvering and greater operational flexibility than is possible with a solid rocket. Also, intermittent operation can be achieved by hypergolic solid-liquid combination or by maintaining low-level solid combustion between oxidizer injections. Such operations can be internally or remotely controlled. Thrust can be varied over a wide range by control of oxidizer flow, and increased firing duration in conjunction with the variable thrust is further enhanced by a liquid-oxidizer regeneratively cooled nozzle.

Closer mixture-ratio control can be more readily attained in the hybrid system than in a liquid system because the oxidizer flow alone must be controlled. Thus, there is better utilization of the stored energy, and maximum system performance results. In addition, the hybrid engine can eliminate "hard" or explosive starts by providing an extensive solid surface for hypergolic ignition.

Hybrid, and especially storable hybrid, systems will be less susceptible to malfunction due to hidden defects that occur during or after manufacture than will a solid rocket. Further, by separating the oxidizer and fuel in the rocket, there is less hazard from ignition or detonation. For the ultimate in safety, the liquid oxidizer can be removed completely from the rocket for long-term storage and refilled at any time prior to shipment for use. The author and Cavecche[33, 34] have recently described different configurations of hybrid systems and a typical one is shown in Fig. 4. The tank with the liquid oxidizer is located in the forward section of the propulsion unit, using the fore-end closure of the chamber as part of the tank. The liquid is pushed into the perforation (core volume) of the solid grain, either by stored gas or by gas from a gas generator. Ignition may be by an igniter as shown in the figure, by a hypergolic slug contained between two

Liquid oxidizer boosts hybrid thrust
Fig. 6



burst diaphragms, or preferably by the use of a hypergolic oxidizer.

The place of a hybrid-propulsion system in the family of chemical rockets is shown in Fig. 5. Thus, for the same velocity increment (burnout velocity of the given stage) the hybrid system will provide a higher density-impulse and a more-compact engine.

A thrust and pressure-time curve, typical of the hybrid feasibility results, is given in Fig. 6. This test used a standard igniter inserted through the throat of the rocket. The first peak in the curve indicates the method of ignition. Oxidizer was allowed to flow for about 3 sec and then the fire switch was closed to shut the oxidizer valve. The grain was then able to burn as a hybrid and as a solid rocket, providing an indication of the increase in performance when the liquid oxidizer was added.

In one test, the experimental average standard specific impulse for the solid grain without any liquid oxidizer was 225 sec. and, with the injection of 18 to 19 weight % of liquid oxidizer, the maximum specific impulse was 246 sec. The theoretical standard specific impulse at the same condition was 267 sec., which resulted in an over-all efficiency of 92.2% for that storable hybrid-propellant combination.

Chemical-Nuclear Hybrids

Refs. 27, 43

Green and Carter[27] suggested a chemical-nuclear hybrid-rocket propulsion system in which propellants are first vaporized in a nuclear (solid) core reactor and then brought together in a thrust chamber. This approach permits the generation of reaction products with high enthalpies.

The possible advantages over conventional chemical- and nuclear-propulsion systems to be gained through the use of a hybrid nuclear-chemical system include:

1. The performance limitation imposed on light metal fuels by high latent heats of vaporiation is removed by the nuclear preheating.
2. The performance limitation imposed on pure nuclear heat-transfer systems by mechanical strength properties of the core structure is avoided by operation of the core material at low temperatures.
3. The chemical-nuclear hybrid system can reach high specific-impulse values without using low-density working fluids.
4. Problems associated with the use and handling of cryogenic fluids are eliminated.
5. Reactor power requirements are relaxed by the utilization of chemical energy to supplement nuclear energy.
6. Use of propellants with improved heat-transfer characteristics and reduced radiation sensitivity can permit simplified thermal- and mechanical-core design and engine design.

A practical solution of the chemical-nuclear hybrid system could use water and light metals as propellants. One solid-core nuclear reactor (see the final article) would vaporize water and light metals (such as lithium) separately and react the vapors in the thrust chamber. Here water acts as the oxidizer and lithium as the fuel.

Water and lithium could be pumped under a pressure of 600 psia. into the reactor and heated to 1,500 C. (which is 1,000 C. below the maximum strength point of graphite). Assuming that the thrust chamber will operate at 500 psia. and expand to 14.7 psia., the theoretical specific impulse (shifting equilibrium) would be 423 lbf.-sec./lbm. If higher pressures could be achieved with the same system, then the specific impulse would rise (for 1,000/14.7 psia.) to 455 lbf.-sec./lbm. A comparison of performance for Li, Li-Mg, and Mg, is given in Table IV.

Nesterenko et al[43] use the name "nuclear-chemical hybrid" for atomic ramjets and turbojets where air is preheated to approximately 1,000 C. and then used to burn kerosene (see below).

Ducted Jet Propulsion

Refs. 4, 17, 18, 38, 43, 44, 62

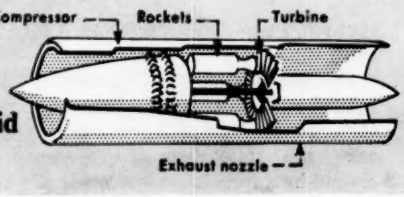
Advances in ducted jet propulsion include the air-turborocket, turbojet with afterburner, turbo-ramjet, hypersonic ramjet, atomic ramjet and ram rocket (also called solid-fuel ramjet).

Air-Turborocket (ATR)—As the name implies, is a combination rocket-turbojet that uses air as additional oxidizer to obtain better performance. Thus, the air-turborocket may be considered a special type of chemical-hybrid rocket. As in the hybrid rocket, the air-turborocket uses an underoxidized propellant, which can be a solid grain, but is preferably a liquid underoxidized monopropellant.

Fig. 7 shows the principle of an ATR. The rocket (or rockets) provide an underoxidized (reducing), fairly cool, combustion gas that spins the turbine rotor. The compressor, driven by the turbine, brings air past the turbine into the secondary combustion chamber, which is between the turbine and the exhaust nozzle. The air fully oxidizes the rocket combustion gases, which are themselves fuel, and thus augments the over-all thrust. The principle of the "turboet with afterburner" is incorporated in the secondary combustion chamber.

Examples of monopropellants are propyl nitrate, ethylene oxide, and acetylene. Acetylene is the sim-

Air turborocket is special type of hybrid Fig. 7



plest example, since it decomposes under the proper conditions into its elements, carbon and hydrogen. There is simultaneous heat release, so that these decomposition products are available as an engine working fluid at a temperature of about 5,000 F. The carbon and hydrogen can next be burned with atmospheric oxygen in a separate phase of an engine cycle to give the usual combustion end products, carbon dioxide and water. This second reaction makes available an even larger quantity of heat.

The gases from the decomposition of monopropellants can be as low as 2,400 F., thereby permitting the use of uncoated molybdenum or molybdenum-alloy construction of the turbine blades.

Development of the air-turborocket engine was originally stimulated by its potential in the relatively short-range surface-launched missile field. By initially operating at high fuel-flow rates to obtain high specific thrusts, and subsequently throttling down to a more economical cruise rate, a wide range of flight patterns can be encompassed with a single air-turborocket engine. Investigation of a number of applications where the air turborocket would be feasible have indicated that a marked saving in takeoff weight and size would result without sacrificing performance capability in terms of carrying a given payload to the required range and altitude.

Turbojet With Afterburner—This type of ducted propulsion uses the afterburning principle, similar to the air-turborocket.

Injection of hydrogen peroxide[62] into the combustion chamber of a turbojet with an afterburner increases the thrust even further. The two direct advantages of H_2O_2 injection are: (1) chemical decomposition of the H_2O_2 adds heat to the engine cycle, and (2) extra oxygen is provided for combustion of the fuel entering the afterburner.

Up to 120% thrust augmentation can be reached by injecting a 90% concentration of H_2O_2. The heat of decomposition, representing extra energy in the engine cycle, amounts to 1,109 Btu./lb. of 90% H_2O_2. The free oxygen stimulates the combustion of reheat fuel.

As H_2O_2 decomposes, 4.7% of O_2 is liberated for every 10% of H_2O_2 concentrate—90% H_2O_2, for example, decomposed to 42.3% oxygen and 57.7% water.

Present fuels for turbojets, with or without afterburner, and for ramjets are composed of petroleum hydrocarbon derivatives. These will probably continue to be the standard fuels for most air-breathing engines for some time. Concurrently, certain high-energy materials show considerable promise for high-performance military aircraft.

Based on the light metals, such as lithium, aluminum and boron, these new fuels, either pure or mixed with liquid hydrocarbons (slurries), provide considerably higher performance than even the best gasolines or standard jet fuels. Although their use presents some operational problems, the performance gain is so great that these so-called "chemical fuels" are likely to become operational soon. Development studies with boron hydrides, for example, have been under way for several years.

Propellant system comparison*—Table IV†

Propellant System	H_2O-Li	H_2O-Li-Mg	H_2O-Mg
Mixture weight ratio, oxidizer/fuel	0.60	0.39	1.9
Chamber stagnation temperature, °R.	7,040	6,080	6,300
Molecular weight	11.1	12.2	27.5
Effective sp. heat ratio in expansion	1.21	1.13	1.05
Bulk propellant density, lbm./cu. ft.	39.0	52.5	71.5
I_s at 500/14.7 psia.	423	362	278
I_s at 1,000/14.7 psia.	455	388	298
Mass flow rate for thrust of 500,000 lbf., lbm./sec.	1,180	1,380	1,740
Vol. flow rate for thrust of 500,000 lbf., cu. ft./sec.	30.3	26.3	22.0
Reactor power to heat propellants, 10^6 Btu./sec.	9.2	7.4	4.3

* Pressure expansion ratio: 34:1. † Chemical-nuclear systems

Turbo-Ramjet—In this system,[16] the turbojet is mounted centrally in a ramjet duct. According to the French flight tests with the "Griffon II" plane, the turbo-ramjet is a ducted propulsion device best suited for Mach 2 to 3. The French plane's ramjet and turbojet share a common intake and a common exhaust. With such a configuration, the turbojet's environment at all times is subsonic. The flow speed at the intake, as well as the exhaust of the turbojet, is around Mach 0.4-0.5. At high cruise speed, the turbojet can be shut off and left to windmill slowly, keeping up the pressure in the plumbing.

The combination turbo-ramjet shows very high thrust at high altitude—even at Mach 2, there is considerable excess thrust, which could provide even higher speeds. At 60,000 ft., for example, the thrust is 5,500 lbf. while at 50,000 ft. it is 9,200 lbf.

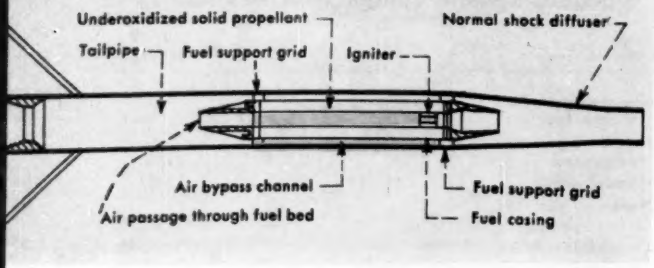
These high thrusts are achieved at a low installed weight. The whole Griffon II propulsion system weighs 3,740 lb., including the ramjet accessories and the aft part of the fuselage forming the 4.5-ft.-diameter outer shell of the ramjet.

Hypersonic Ramjet—Opinions have been expressed[17] that, among air-breathing propulsion systems, the ramjet is the only engine that will be practical beyond Mach 4 and perhaps up to Mach 10 (hypersonic range). The current generation of ramjet engines have an order-of-magnitude advantage in fuel economy over current rocket engines, and the ramjet will retain its superiority well into the hypersonic range.

Research and development are now being carried out in such areas as hypersonic inlets of air, materials and their cooling techniques, and in recombination gas kinetics.

Atomic Ramjet and Atomic Turbojet—In atomic

Ramrocket (solid-fuel ramjet) – Fig. 8



ducted propulsion, the outside air is rammed in through a diffuser, or sucked in and compressed and then greatly heated by an atomic reactor. The hot air is then exhausted through the jet nozzle directly (ramjet) or used to revolve the turbine and then is exhausted (turbojet).

Atomic ramjets have a lower specific thrust than conventional ramjets, mainly because of their air-temperature limit. The structural materials of modern reactors are stable to only 2,200 F., whereas in the ramjets flying today combustion temperatures can easily reach 3,000 F. However, thrust can be boosted by increasing the dimensions of the atomic ramjet so that it handles a greater volume of air.

Maximum cross-section of such a ramjet will correspond to that of either the diffuser or the reactor, depending on speed. Calculations show that, at Mach 2.5 or less, the reactor will invariably be larger in diameter than the diffuser. The only way to increase frontal thrust here is to reduce the reactor cross-section.

Such considerations naturally lead to the idea of a remote reactor system. Ram air, entering the engine diffuser section, can be heated by an intermediate heat-transfer agent circulated between engine and reactor. Since the coefficient of heat transfer from the surfaces of the reactor, to the heat-transfer agent is many times larger than for air, the reactor can be made much smaller. The description of atomic reactors will be given in the next article (nuclear rockets). This article will appear in the May 1 issue and will discuss exotic rocket propellants.

Radioactivity of the exhaust air can be dangerous because of the formation of radioactive isotopes of argon, oxygen (of air and of water vapors) and dust present in the air. However, the radioactive zone behind an atomic ramjet or turbojet is no more dangerous than the flame of a conventional jet. At the point at which the temperature from the jet exhaust has dropped off enough so that anyone entering the air stream does not suffer a burn, the radioactivity has also dropped off enough so that it no longer endangers the human organism.

Radioactive dust is another matter. Any dust settling on the airfield is likely to have a high radiation level of rather long duration. This threat can be counteracted by laying concrete runways, wetting the runway with water before takeoffs, installing suction vents to continuously remove dust, and similar measures.

Shaft Cooling a Problem

Though the atomic turbojet is simple in principle, its practical design is made very difficult by almost insurmountable shaft-cooling problems. The shaft connecting the turbine with the compressor has to pass through the reactor. It absorbs heat from the hot reactor parts, but even more important is that the shaft material itself generates heat due to the scattering and absorption of neutrons and gamma rays.

This problem could be overcome by installing the reactor outside the engine. Then the air could be bypassed from the diffuser to the reactor and ducted back into the engine for exhaust into the atmosphere.

Inevitable heat losses through the duct walls, as well as fluid-flow friction losses, would tend to reduce the cycle efficiency. But the reactor would be far removed from the engine, so that radiation shielding would become simpler.

Thrust can also be boosted by reheating the air after it has passed through the turbine—much as in an afterburner, only with the supplementary heat provided by means of an intermediate heat-transfer agent. Instead of going directly to the main heat exchanger (before the turbine), the heat transfer agent moves from the reactor to a heat exchanger behind the turbine. From there, having surrendered part of its heat, it proceeds to the main heat exchanger.

A similar boost in thrust can be produced if an auxiliary engine, not energized by the air heated in the heat exchanger or the reactor, is used for driving the air compressor. A steam or gas turbine using mercury vapor or helium and operating in a closed cycle is well suited to this application.

With liquid mercury, a pump is needed to force it under high pressure through the reactor, where it is heated and converted into vapor to drive a mercury turbine coupled to the air compressor. The expanded mercury is then condensed and recycled into the reactor.

Any reactor operating on this principle must be a fast-neutron type, because mercury is an avid absorber of thermal neutrons. It may even prove better to heat the mercury in a heat exchanger by means of an intermediate heat transfer agent rather than directly. Then, the neutron absorption will not fluctuate too much with the density change involved in the conversion from a liquid to a vapor.

If a helium turbine and compressor are used, the power must be several times higher than that of a mercury turbine to supply the same power to an air compressor. Far more power (several tens of times greater than that going into a mercury pump) is needed to drive a helium compressor.

Most likely, airborne combination systems will be developed before a pure atomic system appears. It is quite doubtful, though, whether the range of flight

with such a combination engine will exceed that of aircraft with conventional engines.

It is quite probable that atomic jet engines with kerosene afterburners will be used. These engines will have a standard afterburner chamber between turbine and jet nozzle in which the air will undergo supplementary heating. The afterburner will be turned on for brief periods for takeoff, climb acceleration, and flight at maximum speed.

Solid-Fuel Ramjet and Ram Rocket—A ram rocket, also called solid-fuel ramjet (SFRJ), is a ramjet that uses solid fuel instead of liquid fuel. Such fuel can be in form of briquettes made of powdered magnesium compacted with a small percentage of solid oxidizers; the solid oxidizer is required to sustain combustion even without the rammed air. Briquettes or propellant grains can also be made of a solid underoxidized propellant that, as described in the section on chemical-hybrid rockets, achieves maximum specific impulse when air, as the additional oxidizer, is introduced over the burning surface.

Fig. 8 shows a typical ram rocket. Air is forced through the diffuser and goes partly over and around an underoxidized solid propellant grain. The air that goes over the burning surface of the grain adds to the oxidation of the fuel but does not oxidize it fully. Full oxidation occurs when the exhaust gases from the solid propellant mix with additional air in the tailpipe.

The split-flow combustor just described has several advantages. A cool layer of air is maintained along the tailpipe, avoiding problems of tailpipe burnthrough. Perhaps most important, however, is that by allowing only a small flow of air past the burning surface, it is possible to eliminate erosive burning. This, coupled with the improved combustion due to mixing with the large volume of air that had been bypassed, results in combustion efficiencies approaching 90%.

A well-designed SFRJ can, perhaps, achieve a range from two to three times that of an equivalent-sized rocket, under conditions in which ramjets can perform most efficiently. By not carrying its own oxidizer, the SFRJ will substantially outperform a rocket. A ramjet probably has to fly a minimum of about 10 miles (or farther, depending on altitude) before it can compare favorably with a rocket in terms of weight. The upper limit of range is on the order of 100 miles because, in most designs, the SFRJ combustion chamber has to provide space for both fuel and air passage. As with other ramjets, the SFRJ's present useful range of speed is probably between the limits of Mach 1.5 and 4.5.

The SFRJ is basically simple and therefore can be made reliable. Like a solid-propellant rocket, it has no pumps, valves or fuel regulators—not even spray nozzles to become clogged. In most designs, a solid charge is ignited and burns either on one end or inside a simple internal perforation. This is both an advantage and a disadvantage. The fuel does not have to be pumped, but neither can it be shut off and turned on again; nor can the fuel flow be adjusted on demand. However, for steady cruising flight, these disadvantages are not paramount, although they do limit possible applications.

Recombination Ramjet—This type of ducted propulsion is also called interplanetary aeroduct.[8] It is only a conceptual system; no propulsion experiments have been carried out so far.

The recombination ramjet does not carry any propellants aboard the device but relies on ducting atomic or ionic oxygen, nitrogen or hydrogen existing in the upper atmosphere, and combining these atoms into molecules.

Free-Radical Rockets

Refs. 11, 20, 37, 42, 56

To bridge the vast gap beyond chemical propellants, efforts are being made to develop a whole new concept of rocket propellants known as free radicals. The goal is a relatively uncomplicated monopropellant with approximately seven times the energy content of the best rocket propellants now available.

When sufficient energy is added to molecular gases, they first dissociate into atomic gases then with the further increase in energy level, break down into free radicals. The tremendous energy required to break them loose from their normal stable molecular state is returned when the gases leave the high energy gradient and the particles collide and reform into molecules. When they do, all the energy that went originally into dissociation is given back.

Storage of free radicals is very difficult. Supercooling them down towards absolute zero is a possible solution. The technique requires heavy cooling equipment and cryostat storage facilities. Presumably, the free radicals would be produced on the ground, possibly CH_3 (from C_2H_6 or CH_4), NH + 2H and NH_2 + H (from NH_3), H + OH (from H_2O), O (from O_2), H (from H_2), N (from N_2), metastable Ne* (from Ne) or metastable He* (from He). They would be stored in cryostats until required, then loaded into the rocket storage tank. The rocket would operate as described below.

The metastable radicals are stored in a refrigerated tank cooled close to absolute zero. When the rocket is in powered flight, a turbopump transports the free radicals into a heated thrust chamber where they exceed their critical temperature and reassociate, liberating the energy of dissociation. The momentum of the gases is increased when the gases are exhausted through the nozzle and thrust is produced. Since the exhaust gases may reach temperatures of 12,000 F., the thrust chamber will have to be cooled. Some of the exhaust products will be used to drive the turbopump.

Latest experiments with free radicals are not very encouraging. It is thought that cosmic rays penetrating the storage vessels are the worst offenders in the recombination of free radicals during storage. However, experience with this type of propulsion will aid in developing the recombination ramjet mentioned above.

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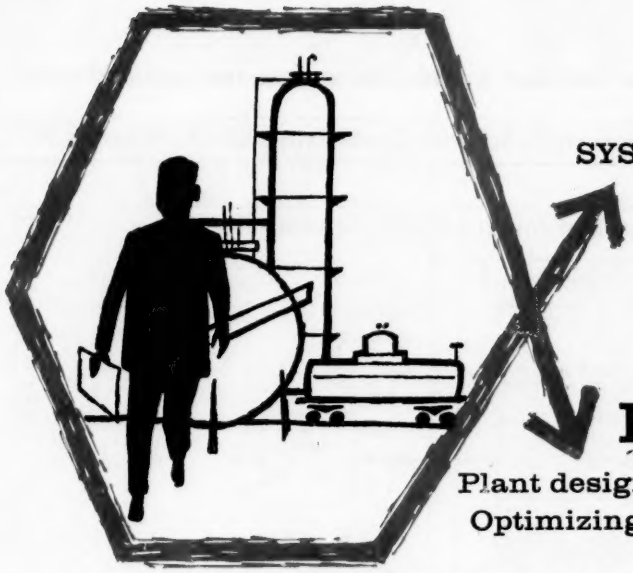


SYSTEMS ENGINEERING, PART 13

Plant Unit Design

Plant design gains from over-all optimizing. Optimizing plant units, too, can up savings.

THEODORE J. WILLIAM, *Monsanto Chemical Co.*

In Parts 4 and 5 of this series,* we showed how electronic computers directly compute the optimum over-all plant design from the standpoint of economic return. Computers—particularly digital computers—have proved extremely valuable for economic optimization of design and, too, for detailed design of specific plant units.

The complete application of systems engineering to chemical processes will require that computers be used for both: for over-all economic optimum design, together with specific unit designs. These two optimizing steps will be interdependent parts of our design procedures. When this dual optimizing procedure is finally achieved, the necessary complexity (but also flexibility) of it will be so far beyond human capabilities that computing machines will be absolutely necessary. Only when we have incorporated these design steps, however, can we say that our plants have achieved optimum design from all standpoints.

The design phase is by far the most complex branch of systems engineering that we have considered in this series. But it is also one of the most important phases because of the potential capital savings to be made in it. Let's now examine the complexity involved, detail the progress made and outline some of the remaining problems in this area.

Plant Design as a Feedback Process

Fig. 1 shows the steps involved in initial concept and design of a chemical processing plant. The block diagrams sketch this procedure as a feedback loop—and in a very real sense this is what it is.

Management first collects available market and research data, then analyzes it for possible new ventures for the company. Prospective avenues of endeavor must then be translated by engineering effort into potential reaction and production schemes, several of which may be possible. Next, a plant design and market analysis must be carried out for each postulated production scheme to determine its profitability. The detail used here depends upon the degree of certainty desired from the answers that are to be obtained.

Finally, the profit and cost data from all of the production schemes are compared to find out which would be the most profitable. The resulting data are then returned by a feedback loop to the initial analysis block. There, the decision must be made to proceed with the potentially most profitable scheme or to seek still another venture, based upon current research and market data.

We have thus defined an "economic-feedback" system. Indeed, if it were possible for the steps carried out here to be reduced to mathematical terms, they would obey all the laws of feedback control, which were outlined in earlier parts of this series (Parts 7, 8 and 9).

In addition to the main feedback loop of data on economic returns, indicated in Fig. 1, the design procedure has two other internal feedback loops:

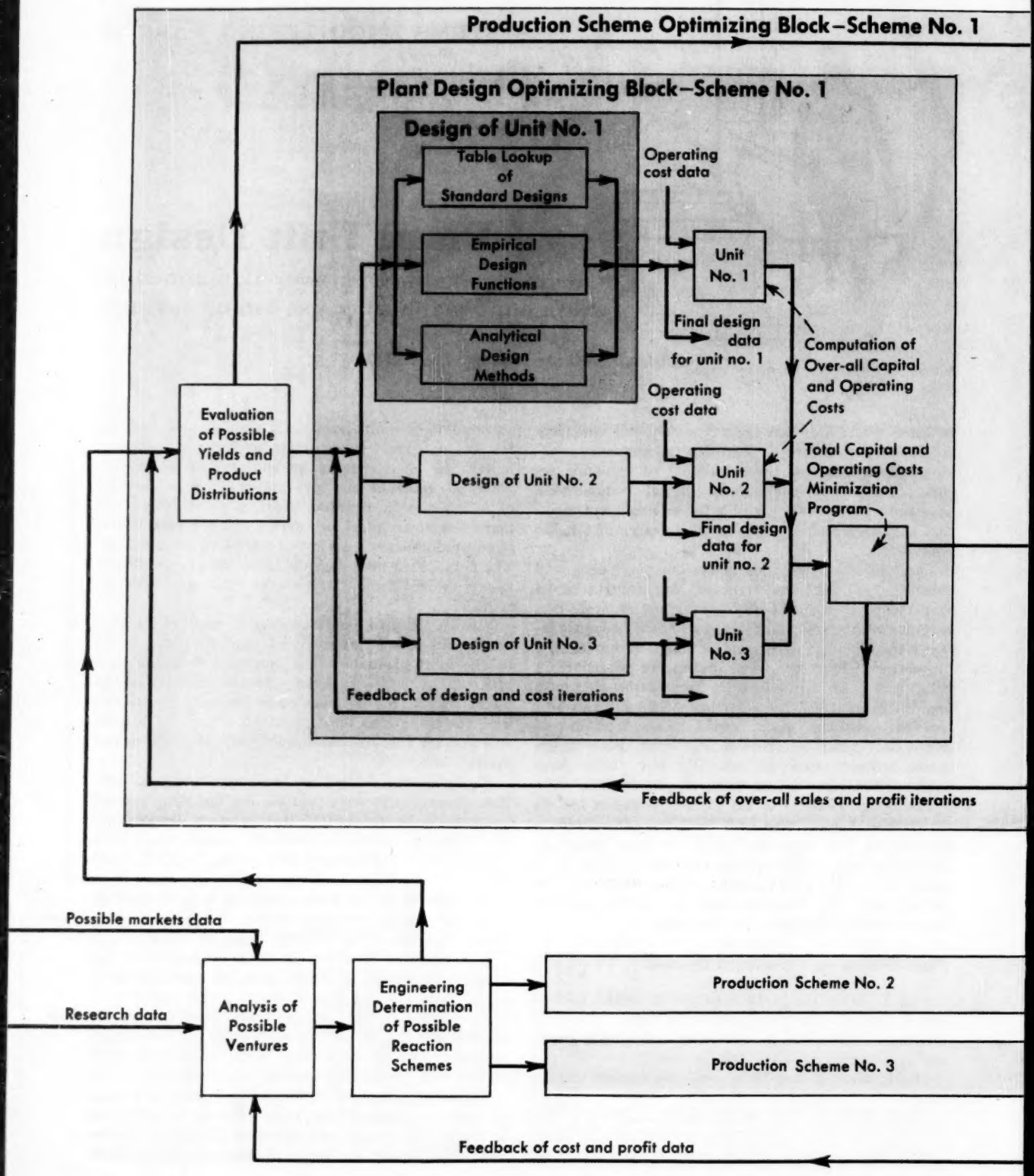
1. A repeated iteration on the possible sets of operating conditions, to assure that the most profitable set of products and byproducts is being used.

2. Internal to (1), an additional iteration on the possible designs of various plant units, to assure that minimum over-all production costs, considering both capital and operating expenses, are obtained.

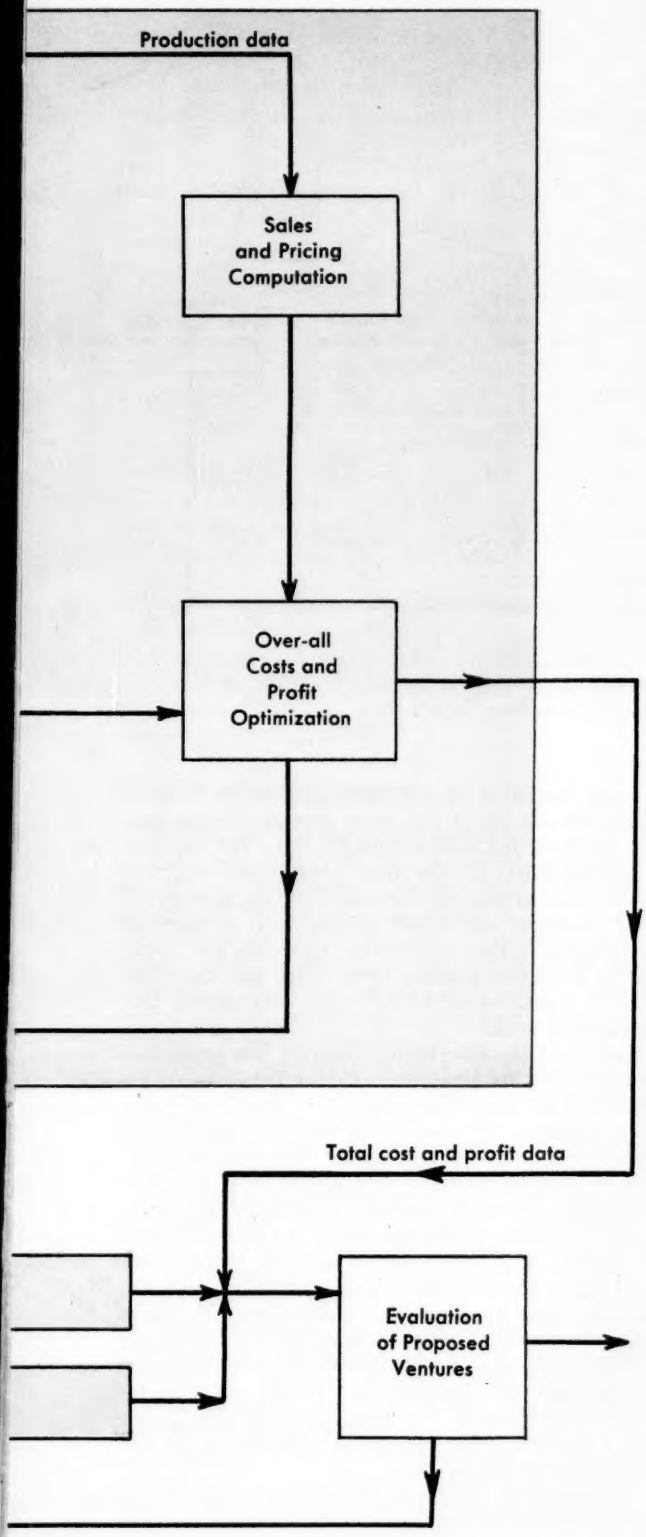
Again, these are true feedback loops since the results of previous computations must be used in each case to decide the amount and direction of change for the next trial design or the next trial operating condi-

* Based on the 1959 Schoch Lecture at the University of Texas, the series has appeared in *Chemical Engineering*, Feb. 8, 1960, pp. 121-26; Mar. 7, pp. 131-6; Apr. 4, pp. 139-44; May 2, pp. 121-6; May 30, pp. 97-102; June 27, pp. 113-118; July 25, pp. 119-124; Aug. 22, pp. 127-132; Oct. 17, pp. 181-186; Nov. 14, pp. 227-232; Dec. 26, pp. 101-106; Feb. 6, 1961, pp. 107-110.

Here's how over-all optimizing scheme includes production and design optimizing . . .



. . . two steps for best economics.—Fig. 1



tions. These two internal feedback loops are shown in the darker colored areas of Fig. 1.

A diagram such as that of Fig. 1 emphasizes the tremendous range of possible choices for picking the optimum reaction conditions, as well as the optimum plant design required for those conditions, for each process investigated. But it also emphasizes how few of the many possible cases can actually be investigated with current design methods. With these traditional methods, we have small hope of securing lowest cost production for our processes.

Computers, though, can help considerably in providing optimum plant designs. The laws of feedback control systems and of statistics can be used to formulate methods for making choices of reaction conditions or design bases. Computers can then mechanize determination of these choices, along with the tremendous number of computations required to evaluate them. Only in this way can we make the many iterations required to assure optimum design and operation.

Over-all Plant Design

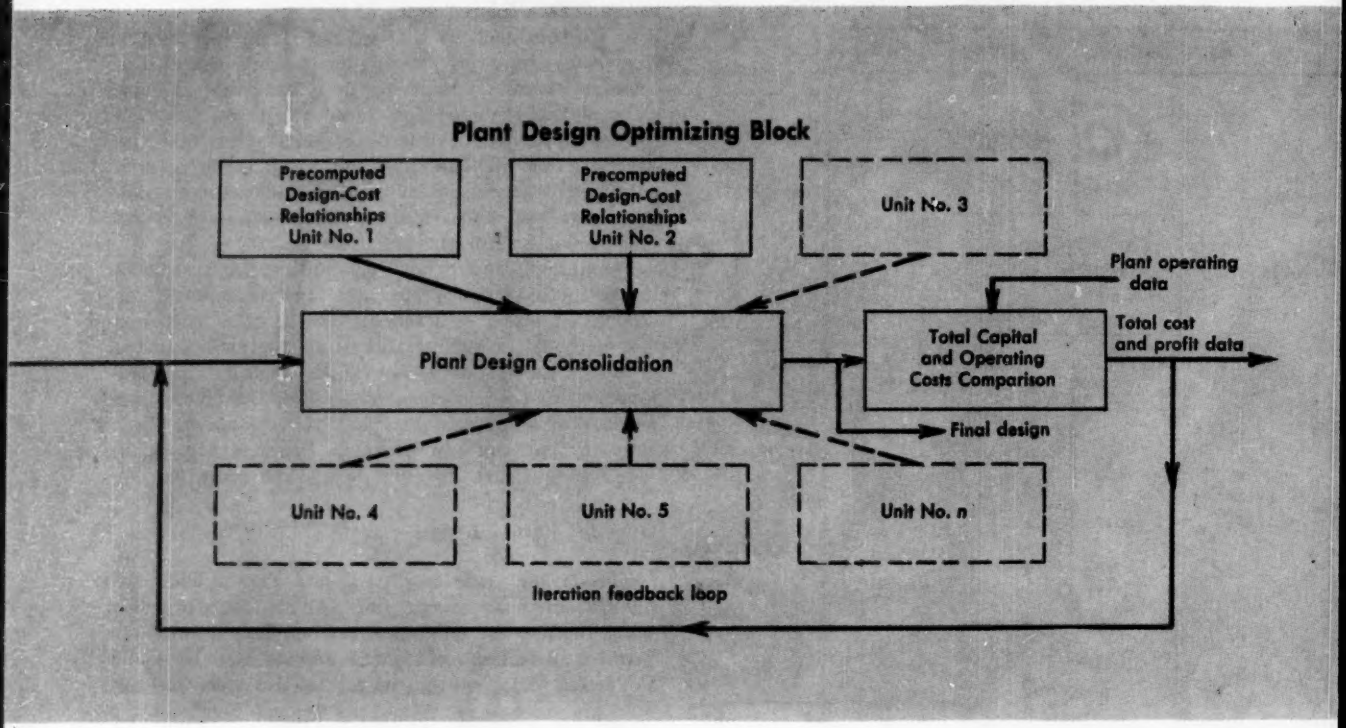
The darker areas of Fig. 1, and Fig. 2, show two possible methods of carrying out the iteration of a plant design. In the procedure of Fig. 1, only one possible design of each plant unit is initially made. Following this, the required capital and operating cost data are computed for the trial design. Next, after a slight design change is made, recomputed cost data are obtained. The first two cases are then compared to determine, for the third trial, the direction that the design must take to obtain even lower costs.

This procedure is reiterated until the lowest possible cost is found. To simplify selection of trials, the statistical methods of evolutionary operation are extremely valuable.[5] With them, choice of new cases is mechanized so that progress is always toward a lower cost plant with each new trial.[1]

By this method, the best plant is designed with the fewest choices of possible plant cases and thus the least computation time. Efficient use of this method; however, also requires that computer programs be readily available to compute a design case for each unit in the plant during each iteration. With the present state of computer programs and computer memory capacities, this is impossible today; but there is no reason to doubt its eventual practicality.

A more practical case today is that illustrated by Fig. 2. Here, the machine precomputes a range of possible unit designs with associated cost data for each proposed plant unit. During the actual optimization, the computer coordinates only these resulting cost data to obtain the optimum plant design. This requires determination of many more cases than the first method to cover the full range of designs, and it probably requires many times the amount of machine computation. But, much simpler to program and operate, it will be preferred for some time to come. Of course, evolutionary operation can also be of great help in this second method so that the proper precom-

From precomputed data: an alternative plant-design optimization.—Fig. 2



puted cases are compared to determine lowest total costs.

The literature contains several important articles that discuss all or part of the problem. Of these, the recent ones by Berg,[1] Kellett and associates,[3, 4] Kern[9] and Taborek[9, 10] are especially worthy of study. Some of the newer optimization methods, using the calculus of variations,[60] have important possibilities if they can be applied to the general design case. Valuable applications have been found in reactor design and operation problems.[48-49, 53, 54]

A study of the literature, however, will show that though many individual unit operations have been well explored by computer design methods, little has been done to implement the over-all design procedures we have mentioned here. Recent progress in design of individual units is heartening, however.

Unit Design Methods by Computer

Design procedures programmed for computer exist for nearly all plant unit operations. Routines exist, too, for the design of plant piping and structural members. As might be expected, the unit operation that has received the lion's share of attention is distillation. Heat exchangers,[36-44] chemical reactors,[45-56] piping systems,[57-62, 64] structural members[63] and dryers[65] are also described. The machine computation committee of AIChE publishes a list of programs, any of which can be made available if sufficient interest is shown.[67]

For effective use of any plant process—design routine, physical and thermodynamic data for the materials involved at the prescribed conditions are needed. Due to work of Gambill[28] and others in developing empirical and exact mathematical expressions for variation of these properties, many are now available in computer routine form. The machine computation committee of AIChE is also engaged in furthering this work.[24]

Because of the attention distillation has received—a reflection of its importance to our industry—it deserves special discussion here. The design of distillation columns[24, 27, 28] was among the first chemical engineering studies to which digital computers were applied. It has continued to be a popular application.[13-35] The combination of extreme complexity and wide choice of possible operating conditions has lent itself particularly well to the use of machine computation.

An algebraic derivation, and solution of heat and material balances across the column and its parts, has been the most common approach in distillation. Because of the way in which the design condition must be expressed, sufficient data are usually not available for closed solution of the resulting equations. Therefore, a trial-and-error solution procedure must be used for this type of program.

The resulting programs have been successful in solving simpler design cases, but the solution for some

types of multicomponent mixtures under nearly complete separation conditions cannot be handled.[20] The algebraic procedures have been developed for both analog[13, 14] and digital[15-20] computers.

Lack of complete success with the most complex and probably most important design cases, combined with recent availability of larger and faster computers, has resulted in development of a differential equation or transient approach to the problem.[20, 21] Equivalent to determining the path of approach to equilibrium[21] of the column upon startup, difference-differential equations (one for each tray of the column) are solved simultaneously. The steady-state result is the column operating condition desired for the design data. Although tedious, this method has been successful in many cases that could not be solved by any of the algebraic trial-and-error ways.

Because of the complex equilibrium relationships and thermodynamic data, and a lack of machine routines for their evaluation, the design cases for absorption and extraction columns are not in as good shape as those for distillation and extractive distillation.

Computation routines for the design of chemical reactors can determine the optimum temperature and composition profiles in tubular reactors,[46-49, 53, 54] and similarly determine the best time-temperature profiles for batch reactors. The optimization of catalyst beds in packed-bed reactors has also been well-treated.[47, 51] Difficulties will be experienced, however, in reactors designed for polymerization of plastic materials, and other cases where only mediocre knowledge of mixing characteristics is available.

Some Complicating Factors

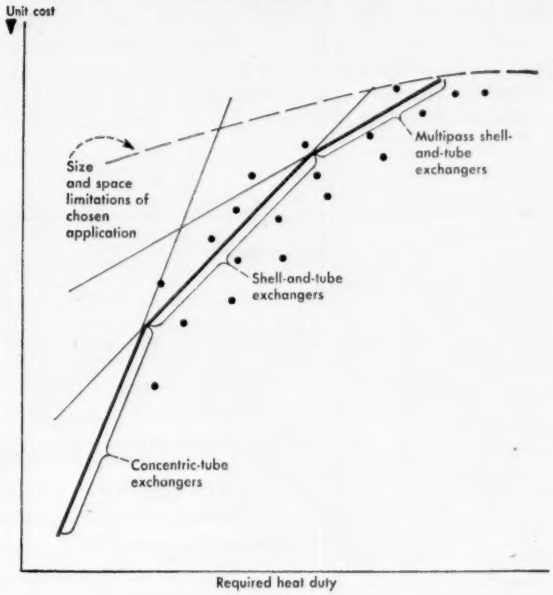
Added to the complexity and repetition of the direct computations themselves, several other factors greatly complicate the problem of mechanizing plant design procedures. For example, as shown in Fig. 3, many possible designs may be available for a certain type of apparatus in a particular application. Depending upon the cost and the required duty factors involved, several of these may be applicable over the range of variables under consideration.

To further complicate it, there are always so-called "standard designs" of process equipment, which approximate the capabilities for the duty at hand. Because of their higher quantity manufacture, they are usually cheaper than a specially developed design. In Fig. 3, special designs are represented by points above the heavy curve, standard designs by those below.

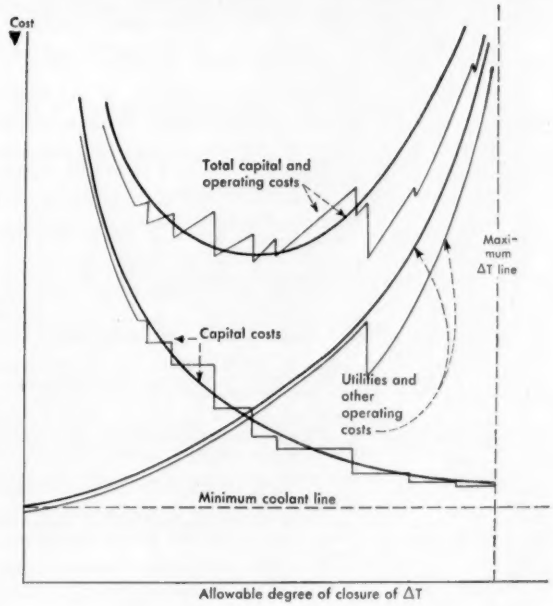
Since the choices may very well not fall on the cost vs. duty curve, the effect is to convert the usually smooth total-cost curve, which one regularly sees in textbooks (in black, Fig. 4), into one that more resembles the irregular one in color in Fig. 4. In addition to the decidedly stepwise appearance of the capital-costs curve, utility costs may vary with quantity, producing yet another complication.

Although the over-all process-design phase is the most difficult of the various branches of systems engineering, the great gains to be made assure its con-

Commercially available heat exchangers may offer many choices for heat duty.—Fig. 3



Real-world cost curves usually don't show smoothness of those in textbooks.—Fig 4



near future. At the same time, it must be kept in mind that the numerous ramifications of the problem (e.g., Figs. 3 and 4), and the one-time nature of many of the decisions to be made (Fig. 1), will prevent its complete evaluation on computers for some time to come. Too, there is great need for continued development of basic data and computer routines for expressing the physical, chemical and thermodynamic properties of chemical materials.

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Construction Schedules Improve Work

Process plant construction benefits by using good planning for schedules that can compare actual with estimated progress.

JOHN W. HACKNEY, *Pan-American Management, Ltd.*

Construction, like other corporate activities of a chemical company, proceeds more smoothly and quickly when it is preceded by good planning. As the work progresses, the benefits of good planning are extended by comparing actual with planned progress and taking action to correct any unfavorable developments.

A technique, developed over a period of years, for construction scheduling is described here. It coordinates with accounting procedures for cost estimating and recording as described in "Capital Cost Estimates for Process Industries," *Chem. Eng.*, Mar. 7, 1960, pp. 114-115.

The technique is flexible enough to use in scheduling projects of various types, ranging from small to medium in size. Very large, complex projects such as process plants that cost more than about 10 million dollars justify the application of similar principles but with the aid of computer techniques.

Tabulate Key Dates

The simplest form of construction schedule is a tabulation of key dates. In many cases, this is all that is required beyond the informal mental scheduling that will be performed by everybody concerned with a project. For example, the program establishing a new tank-car loading area in an operating plant might look like this:

Start detailed design	Jan. 1
Complete tank design, requisition tank	Jan. 15
Complete all design	Mar. 15
Start construction	Mar. 15
Start tank erection	Apr. 15
Tank to be ready for use	Apr. 30
Loading station, tracks ready for use	July 1

For discussion purposes, it is sometimes desirable to put this tabulated data into graphical form. A tabulation like this is very useful. It indicates when the designer will start and when he should finish. It has a key point, tank completion, to guide the emphasis in setting up the design program. It provides the basic information to set up a detailed construction schedule if one is needed.

For the purchasing agent, the tabulation points up some key facts. He will have a requisition for the tank on Jan. 15 and must find a vendor who has the plate and can start field erection in three months, completing the tank in two weeks. Delivery time for the loading-rack steel may also be critical.

Proper scheduling prevents costly delays.

Since this project is in an operating plant, the operators enter the scheduling picture. When the new tracks, a tank and a loading station are being established, it upsets to some extent the day-to-day business of maintaining production. This is especially true in a modern process plant where every part is so interconnected that the plant is sensitive to disturbance in any part.

The operating group gets their basic information from the starting and ready-for-use dates of the preliminary schedule tabulation. The starting dates indicate when some disruption of their operations may begin. The ready-for-use dates indicate when startup crews should be ready. They study these dates and appraise their effects on plant operations. Sometimes they will ask for modifications in the preliminary schedule so as to reduce equipment downtime and other causes of loss of production. If the problem of getting

a mutually satisfactory over-all schedule is at all difficult, a joint conference of the designer, purchasing agent, construction engineer and operating supervisors is necessary.

Detailed Construction Schedule

When the over-all schedule for the project has been agreed upon, the construction engineer must schedule his own part of the work in more detail. He must be sure the sequence of work is exact. Otherwise, he may find himself trying to install pipelines on nonexistent pipe bridges. He must also determine the approximate number of men of each craft needed to do the work in the allocated time. It may even be necessary to ask for a revision of the over-all project schedule if the detailed schedule shows an unreasonable amount of manpower would be required for some operations. On the other hand, the detailed schedule may show opportunities for overlapping of operations that will permit earlier completion.

Use of the construction-schedule form in preparing a project schedule is illustrated [Right]. The title block is self-explanatory. It should be filled in completely because, after project completion, this schedule graph will become a part of the file of job records and be available for planning.

The form has space for 12 four-week months. Longer construction periods can be covered by using additional sheets.

Using a 4-week month, as indicated by the form, considerably simplifies the mathematics of preparing the schedule. It also provides an automatic time margin of about 8% to cover ordinary contingencies such as holidays and bad weather. Additional time allowances are required for outdoor work when bad weather is expected and for other special cases.

On the left side of the schedule sheet are typed the account numbers and titles for the various subdivisions of the program. The account numbers come from the standard account subdivision system.* This system has been so devised that when accounts are listed in numerical order they are very nearly arranged in construction sequence. A group of accounts is set up for each major section of the larger projects. Each group is made up of all the construction operations needed to build that particular operating unit. Work must be scheduled within each section so that it will be continuous—with foundations ready when structural steel arrives, structural steel erected when equipment is ready to be set, and so on.

In addition to this scheduling for each individual section, it is also necessary to schedule by type of work. Concrete work for all sections, for example, must be scheduled so that concreting for the job as a whole will be as continuous as possible. The same applies to structural steel work, piping, insulation and so forth. On the larger projects, this cross-scheduling can be complicated. Separate detailed cross-schedules for each trade may be necessary.

* For a more complete description of this account system, see *Chem. Eng.*, Mar. 7, 1960, p. 116.

CONSTRUCTION SCHEDULE AND STATUS REPORT

APPROP. NO.	40-40-400	SUPPL'T NO.	
TITLE	New Tank Car loading Area		
DIV.	Chlorinated Products	WORKS	Nova
SCHEDULED BY:	R. G. Smith	DATE	2-22-60
REVISED BY:		DATE	

ACCOUNT	DESCRIPTION	EST. M.H.
	TIME SCHEDULE	MONTH: Jan.
		DATE
		ACTUAL PROGRESS
		ELAPSED TIME
03-10	Site clearing	800
13-10	Equipment foundations	800
16-10	Supporting frames loading	720
21-10	Storage tanks (steel)	2,000
31-10	Steel piping	1,600
35-10	Area sewer piping (concrete)	720
39-10	Insulation for piping	360
58-10	Pump loading station	160
59-10	Instrumentation and metering	120
61-10	Area lighting	320
66-10	Power wiring for pumps	160
72-10	Access road to station	1,800
73-10	Railroad siding	2,640
78-10	Painting	680
	TOTAL	12,880

FIELD FORCE: 60, 50, 40, 30, 20, 10, 0

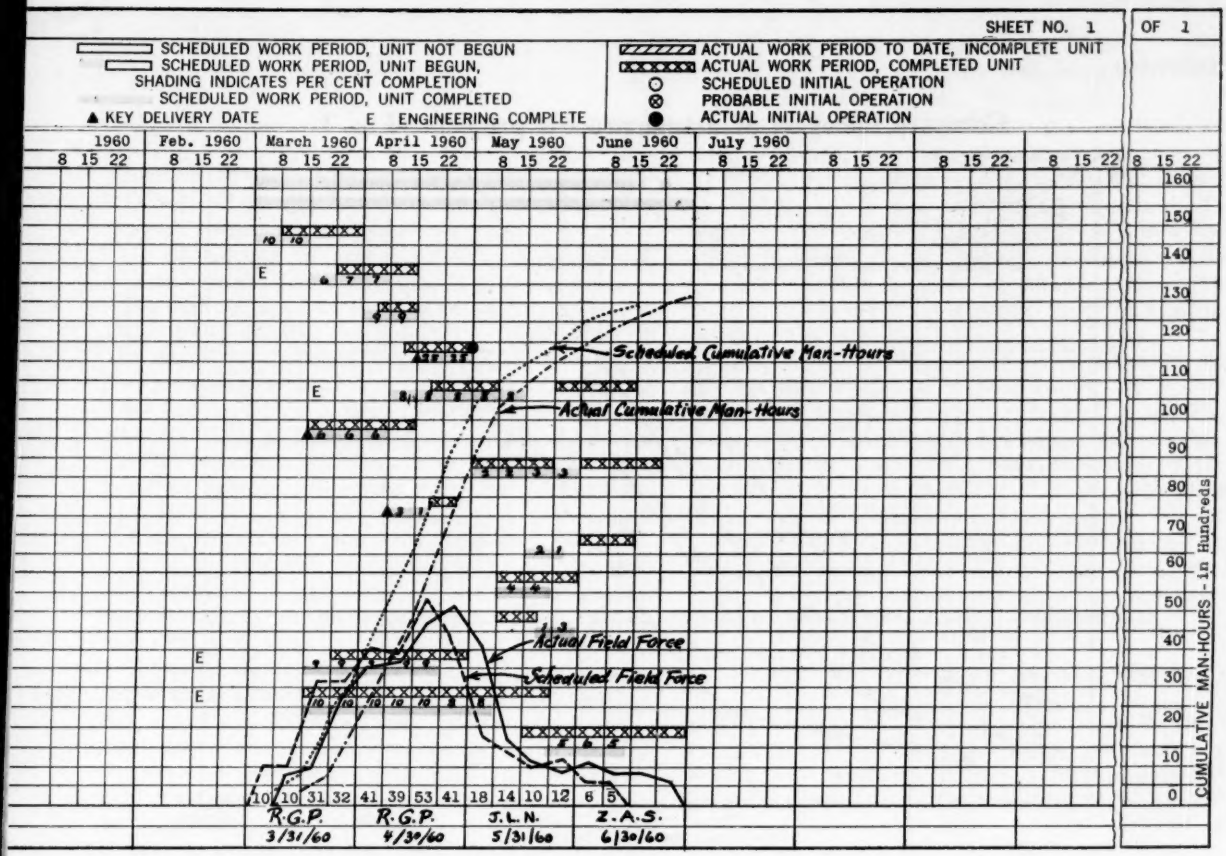
V.C. Mois-Oper.	STATUS REPORTED BY:
B.C. Main-Oper.	SHOWING PROGRESS TO:

As mentioned previously, the descriptions and account numbers for each of the items to be scheduled can be typed directly from the cost estimate if the estimate has been prepared on an account subdivision basis. The cost estimate also provides estimated man-hour figures for each item. These are entered in the third column.

Engineering Design and Equipment Ordering

First step in scheduling the project is to note the expected delivery dates for each of the key items of equipment and material. These can be indicated by a small triangle in the middle of the appropriate schedule line, with an abbreviated notation to indicate what the item is. These key items may be process equipment, tanks, structural steel, switchgear or other long-delivery items. In establishing the probable delivery dates for key items, allowance must be made for delivery time from the fabricator to the plant site. This can be an important item when the work is overseas or in a remote area.

If all of the detailed engineering for the project has been completed and the drawings released to the field, scheduling can proceed on the basis of material delivery dates only. This is usually not the case since by starting some construction before detailed engineering is complete a project can often begin producing at an earlier date. The added return and early product marketing that result will sometimes more



than compensate for the difficulties and expense of concurrent construction and design.

Sometimes, the detailed engineering for a project is only partly complete at the time a detailed construction schedule is drawn up, and only part of the drawings are available for release. With the assistance of the design engineer, the dates on which the balance of the drawings, bills-of-material and requisitions for each subaccount will be available can be noted on the schedule with an *E*. Notation of these dates determines a set of receipt dates for material covered by these requisitions. These receipt dates are established by allowing for the time required to place purchase orders, manufacture items if they are not in stock and deliver them to the job-site.

The time between the signing of a requisition and placing of a purchase order depends upon the relative scarcity of the material, the buying organization and the amount of negotiation that must take place between the purchasing department, the design engineers and the vendors. The best way to determine average procurement time is to examine records of current jobs of a similar nature, tabulating the spreads between requisition and purchase-order dates. Average procurement time may be on the order of 2 to 4 wk. For certain types of equipment, it will stretch to 8 or 10 wk., or more.

Time required for a vendor to fabricate and ship is usually specified on the purchase order if one has been written. Otherwise, it is necessary to assume a fabrication time or, for the more important items, to check the probable time of manufacture with vendors. Delivery time is usually on the order of 1 to 2 wk.

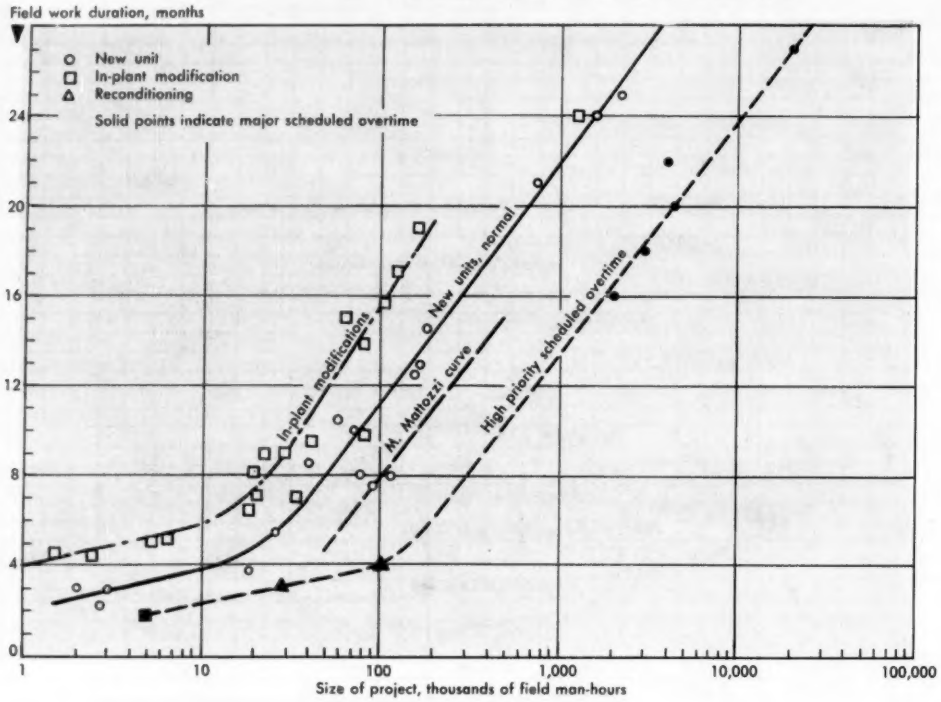
Sketching the Schedule

Having established the key dates of engineering and procurement, it is possible to begin sketching the construction schedule. This sketch will require continuous revision as it develops.

A good starting place for a process project is the arrival date of the major items of process or other special equipment. By estimating the erection time of these items, a date is obtained on which the process piping can begin. A reasonably sized crew for piping is assumed. This assumption will be on a trial basis and the crew will be large or small depending upon the size of the project as a whole. The number of 40-hr. weeks required to do the work with this crew is computed by dividing the estimated man-hours for the subaccount by 40 times the number of men in the crew. An open graph bar, corresponding to the work-weeks required, is drawn to the right from the piping starting date.

Knowing the date when the major process equipment is scheduled to arrive at the job, we can work back toward the left in a similar manner to estimate the time required for erecting the supporting structural steel. The time required for forming, pouring and stripping the foundations for the structural steel

Compare duration of actual process projects—Fig. 1



can then be estimated and marked on the schedule to the left of the steel erection graphbar.

At this point, conflicts usually begin to appear. For example: quite often, the promised delivery date for structural steel is too late to permit reasonable scheduling of the balance of the program. It is possible that this can be corrected by accelerating the completion of steel drawings or by reducing shop fabrication time.

Continuing on this same basis, the schedule is worked out using open bars to indicate the time required for each operation. This first sketch will establish a tentative startup date. This startup date may not be acceptable.

By this time, however, the key items controlling the progress of the schedule as a whole will have become obvious. Hence, the scheduler can take action with respect to improving them. For example, some items can be improved by increasing the size of the field crews, although if carried to extremes this will result in decreased efficiency and increased costs. Overtime work or extra shifts can be used in similar fashion, especially where limited space prohibits the use of larger crews.

If the excess cost of speeding up the job by these means will be substantial, its dollar value should be computed so that the construction engineer and other interested personnel will know what the company is paying for the improvement. It may be a good investment. It may not.

Improvements in deliveries for items that might delay the schedule are obtained through the purchasing department. Expediting should be requested only when necessary. Otherwise, the purchasing department and the vendors will show a lack of enthusiasm when the scheduler calls for expediting. Promises of improved delivery should be accepted with caution. Sometimes it is too easy for a vendor to get rid of a persistent expeditor by making new promises. Checking of the progress of the work through the vendor's shop may be necessary. Sometimes, an expeditor must be assigned to follow important shipments from the vendor's plant to the job-site.

Completing the Schedule

When the schedule attains a certain degree of firmness, the average number of men for each operation is computed and noted in the graph bar to which it applies. The number of men at work on each of the items for each week is totaled at the bottom of the sheet. These totals bring out any manpower peaks, sags or gaps that tend to reduce efficiency, but that can be eliminated by readjusting the timing or size of the crews so as to establish a reasonably smooth rise and fall in the field force. This must be done within the limitations of the engineering design schedule, the procurement requirements, construction sequence and the required completion date.

The schedule should also be checked to be sure that

not too many new operations start simultaneously. The start of a new operation on the site requires extra attention by the supervisory force. The work will be handled better, with less confusion, if starting dates for new operations are distributed.

In establishing the date on which an operating unit can be turned over to the operating department, an allowance of from 1 to 4 wk., depending upon the size and kind of project, should be made for cleaning up the minor but essential items of unscheduled work. The proposed initial operation date is indicated on the schedule sheet by a large circle on the elapsed time line. For new, untried processes, and sometimes for the better-known processes, there is additional time required between this initial operation date and the date when the unit is in full and satisfactory operation.

When the schedule has been completely developed, a curve showing the size of the field force for each week should be plotted across the sheet. A cumulative man-hour curve can also be plotted, showing the scheduled total man-hours to date at the end of each week.

Construction facilities such as change rooms, parking lots and so forth can be planned to accommodate this scheduled number of men. Construction equipment, field supervision and the clerical force can also be scheduled to fit the requirements of the field force.

In some cases, it will be necessary to plot separate manpower curves for each craft, so that hiring can be planned to provide men with the required construction skills. This is best accomplished on separate charts.

Actual Project Information

The graph in Fig. 1 shows actual duration of field work, vs. size of project as measured in man-hours for a series of actual projects carried out during the last 15 yr. by seven process corporations. Projects were assumed to be complete when they were in full operation and the dollar value of field labor was 98% expended.

The line marked M. Mattozzi is from his excellent article on scheduling published in *Oil & Gas J.*, Apr. 1953.

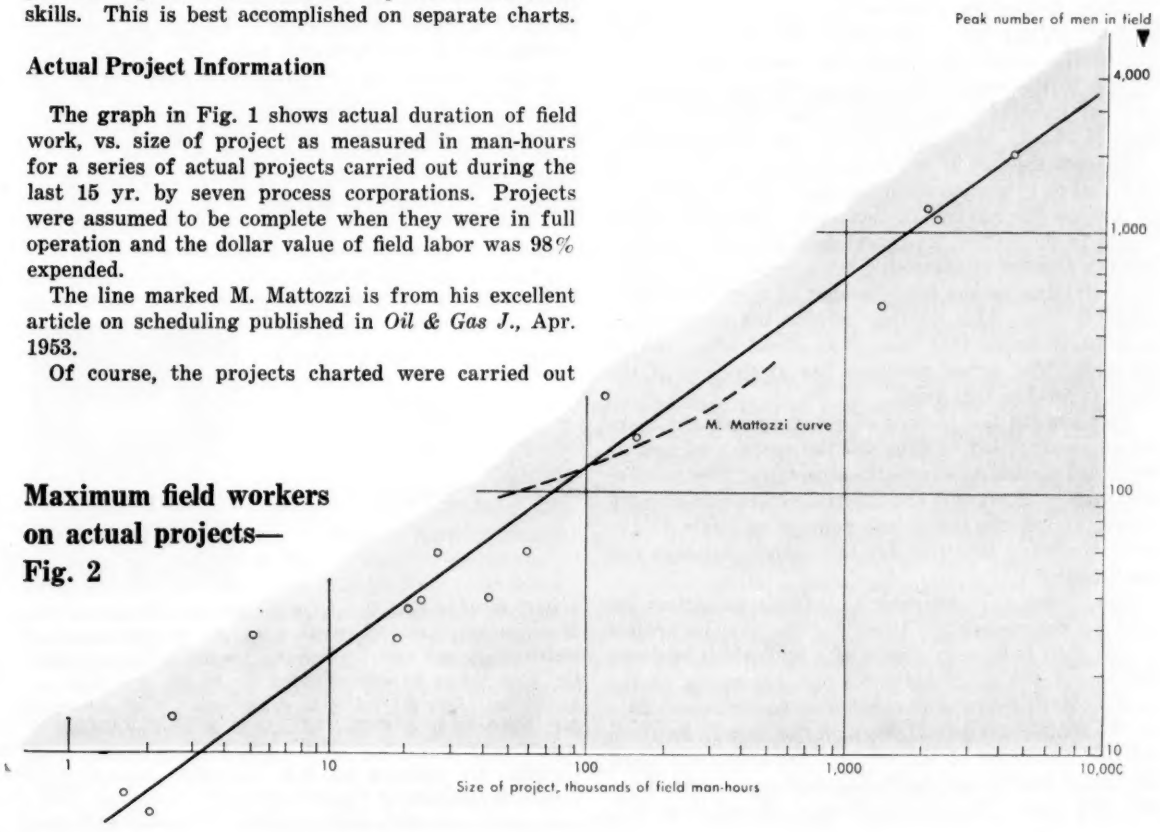
Of course, the projects charted were carried out with varying degrees of pressure for completion and regard for efficiency. Those in the vicinity of the High-Priority line either required substantial amounts of overtime, or were very well-managed, or both. The points marked New Unit were either on a new open site or in a distinct plant working area that was not seriously involved in plant operating activity. The trend lines are useful as a general check on the feasibility of suggested schedules.

Fig. 2 shows the relationship between project size and the peak number of men in the field. The latter includes all people working in the field on the construction of the project whether employed by the contractor, the owner, subcontractors or engineering firms. The dashed curve is from the Mattozzi article and checks the points that lie within its range.

The trend line in Fig. 2 is useful in checking the size of field force established with the aid of the detailed charts, and is also available for quick figures for the design of temporary parking lots and so forth.

Use Chart to Report Construction Progress

After construction has begun, the schedule chart performs its second major function. It is used on a week-to-week basis to indicate actual progress as compared with scheduled progress. With this continu-



Maximum field workers on actual projects— Fig. 2

ous indication of project status, corrective action can be taken as soon as needed; and there is plenty of warning of any forced change in the startup date.

To indicate job progress, each open bar is filled from the left in proportion to the current percent completion of the item. This is equivalent to assuming that each individual work item is scheduled for uniform progress. For example, if an item is scheduled for 10 wk., it should be 10% complete at the end of one week. This is usually a satisfactory assumption, provided the project is broken down into a reasonably large number of individual operations.

A construction job as a whole usually progresses at a slow rate at first, speeds up in the middle and slows down again near the end. When the project is divided into separate construction items, each scheduled for uniform progress, the combined schedule will usually indicate a job-progress curve of this type.

For very large, very important items that cannot be easily subdivided, and that will not proceed at a uniform rate, it is possible to indicate by small figures along the top of the schedule-bar the percentage completion at various time intervals. Consider the 10-wk. item mentioned previously. The end of the first week of scheduled work might be marked 5% to indicate that only that amount of progress is expected in the 10% lapse of time, and so on. In some cases, production units such as cubic yards of concrete, excavation or fill can be used instead of percentages.

When each of the schedule bars has been marked to indicate its percent completion to date, the bar at the top of the graph that indicates elapsed time is extended to the report date. If the filled-in portion of any bar extends to the right of this report date, the item is ahead. If it is to the left, the item is behind.

The net amount by which the project as a whole is ahead of or behind schedule can be roughly determined by adding the number of incomplete scheduled work-weeks to the left of the report-date line and subtracting the number of completed work-weeks to the right, then dividing by the total number of currently active schedule bars. This quotient will be the approximate number of weeks that the job is ahead of or behind schedule. The actual progress bar at the top of the sheet is filled to this point.

To complete the picture of job progress, the man-hours accumulated to date and the number of men at work are plotted as the work progresses. The cumulative man-hour curve is the integral of the men-at-work curve. It reflects the actual number of hours in the work week and time lost due to weather, holidays and absenteeism.

Sometimes, it is desirable to indicate the actual beginning and completion times for the various project items. This is done by means of a half-width bar over the top of the scheduled-work bar, beginning at the actual starting date, and continuing to the report date or the completion date if work on the item is finished. At the conclusion of the project, the chart will show scheduled and actual, beginning and completion dates for each item. The completed chart, shown on p. 156, is of great assistance in preparing a realistic schedule for the next job of the same type.

Analyzing Progress

In combination, the actual progress bar at the top of the sheet and the cumulative man-hour curve can be very illuminating. Assume that the actual progress bar indicates the job is ahead of schedule by several weeks. If the end point of the man-hour curve lies below its scheduled level for the current state of completion, it indicates that the job is not only ahead of schedule but also is being done with fewer man-hours than estimated. If the end point of the actual man-hour curve lies higher than a point on the schedule man-hour curve directly beneath the end of the actual progress bar, it indicates that the man-hours required have been more than expected, and perhaps job efficiency is being sacrificed for speed.

When actual progress is behind schedule, a similar check can be made. If the end of the man-hour curve lies higher than scheduled for the stage of completion indicated by the actual progress bar, it means that not only is the job behind schedule, but more than the expected number of man-hours are being used up. This situation requires correction.

If the curve lies below the scheduled level, it indicates that although the job is behind schedule, the number of man-hours required is less than expected. In this case, the situation may be corrected by expediting delivery of materials or accelerating release of drawings so that a larger field force can be used.

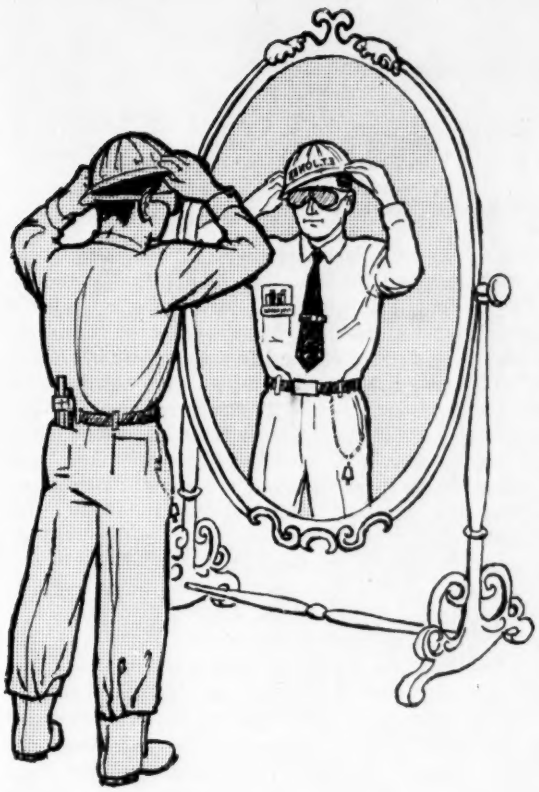
To get the most out of a progress schedule, it should be kept simple. The method outlined in this article gives all of the ways of using this type of schedule. However, only the features applicable to the job at hand should be used in any particular case. Large or critical projects justify full use of the schedule form.

Meet the Author

JOHN W. HACKNEY, *is vice president of Pan-American Management, Ltd., Montreal, Can. He was manager of construction and cost engineering for the Diamond Alkali Co., with whom he was affiliated for 13 yr., and spent an additional 11-yr. period with Aluminum Co. of America. Mr. Hackney is a Fellow of ASCE, a past-president of AACE and a member of the Engineering Institute of Canada. He received his B.S. and M.S. degrees from Carnegie Institute of Technology.*

The Status Of Status

Wherein it's revealed to all that no one beats the engineer when it comes to self-chosen trademarks.



I saw in the newspaper the other day that some firms are fighting the high turnover rate of engineers by hurling a barrage of status symbols at the discontented.

Now we're all familiar with what some of these corporate-imposed symbols are: specially colored nametags, "segregated" parking lots, higher-priced dining facilities. A few firms have even cut duplicate keys to the executive washrooms for those technologists they particularly wish to please.

But what about bootstrapping in this matter of trifles? Often thought clever in other ways, engineers have few peers in devising I.D. markers for themselves. And readers of these columns have long since resigned themselves to the most obvious of these—the hard hat and the slide rule.

To give our art editor a little more scope in his job, several of us kicked the subject of symbols around at coffee break a while back. Aren't there other emblems that convey "engineer" at a glance? I'm not so sure now that we've helped our artists: the compleat engineer above seems to be the result!

In Unity—Oneness; In Age—Antiquity

The closest thing that engineers have in unity is their almost-universal sharing of status symbols. No matter whether to chemical or civil, the hard hat means "engineer." And whether for electrical or mechanical, the slide rule is indispensable. Maybe unification advocates should breech this opening in the perennial opposition to doing anything together.

But at least you'd think that the new engineer could come up with some new, exciting marks of his trade. Most of the symbols turned up in our brief and informal brainstorming session were pretty creaky with age.

New variations, however, crop up from time to time. Take the slide rule. Where once the engineer, as student, carried it fastened to his belt, and later left a shortened model protruding from his breast pocket—now he wears it to clip tie to shirt. He finds it hard to compute with it, let us admit, unless he loosens it and rights the overturned scales. Here's a case where function has left form; only the symbol remains.

Maybe it's just as well. As someone noted, the analog computer patchboard or even just a few connector wires for it are now left casually on the engineer's desk to maintain a link to his traditional role as calculator.

The new engineer, of course, has brought some new symbols—but they're concerned more with tonsorial and sartorial splendor than with the tools of the job. Next time *Life* does a story on monkeys, for example, look around the launching pad. Chances are, the missile-and-rocket types (engineers, not monkeys) will be dressed in open-necked and rather gaudy sportshirts. (The hard hat is part of their gear, too.)

Another of the missilemen marks, along with that of the younger men in R&D of more-prosaic industries, is the crewcut head. Speaking from my own experience, I'd say the crewcut probably makes hard-hat wearing easier. Although that might seem to be some explanation for the proliferation of crewcuts, remember—most of the R&D boys never have to wear those helmets!

More likely, they're wearing ties. And do they keep them neat and orderly with a slide rule tie-clasp?

Well, some do; some don't. The few who don't, have a chain from which hangs the "bent" of Tau Beta Pi.

Once an Engineer, Always . . .

Older engineers, even some who have left engineering and are now administrators, hold on to the special status of that little pin. But theirs hang with more dignity from a watch chain looped across the vestfront. As one more vestige of the life they've left behind, a black-framed professional license hangs on the wall near their desk.

Once in a while, they'll turn their thoughts to the days when they, too, searched for some ikon that would separate them from other men, still retain the identification of their special group. As today, that symbolic part of them was probably rationalized as necessary to successful performance of duties.

In the plant, for instance, both engineer and operator have to carry, perhaps wear, safety glasses or goggles. Although the company stocks standard eye-protectors for all who need them, the engineer has bought a nonstandard pair (perhaps they are tinted).

Communication becomes the heart of status when the engineer is still a fledgling. Carried over from student days, a clear-plastic protector fits his shirt pocket. In it: a four-color pencil, a couple of ballpoint pens, three mechanical pencils (each furnished by a different pump salesman) and a handful of pipe cleaners. (The pipe itself, of course, is a fairly accepted symbol of the engineer.)

And to write on with all these pencils? A couple of pieces of paper fixed to a clipboard. The board probably also holds the daily maintenance schedule.

Although its qualifications as a portable desk are clear, the clipboard is often, too, an important prop for "bits" in the show biz of daily drama. It's used to point out plant areas to visitors—the arrowhead of an otherwise vague gesture. And a stranger immediately spots the engineer in a group of workers within battery limits; although dressed in the same faded khakis as the others, the engineer's got a clipboard, perhaps locked within arm akimbo.

The Frailty of Fads

Some symbols come and go. Like teenagers' fads, they enjoy a brief, widespread popularity but don't seem to catch on as tradition. Although popularized by a well-known physicist, the porkpie hat became a special status symbol for all technologists in the early years of the atomic age. Perhaps engineers wanted to identify with the scientists who had been forced to do much of the practical, hardware work of some wartime weapons projects.

What about those Wellington boots on the artist's engineer? I'm afraid he rang those in on us. Isn't that just a symbol for the civils? Or am I wrong? Let me know if our session failed to turn up the engineer's symbols in your outfit: there's no money, but there's certainly status in symbols.

OVERTIME COMPENSATION FOR EXEMPT EMPLOYEES

An American Management Assn. research study, recently prepared by E. M. Gottlieb, reveals some interesting patterns of paying salaried professionals for overtime work.

"Exempt employees" are those not covered by federal or state compensation laws. But despite the theoretical tenet that professionals receive sufficient regular remuneration to motivate them after-hours, many firms pay extra anyway. How they do it is the subject of this study.

In the 434 primarily manufacturing firms covered (representing 1.8 million total employees), 52% (224) pay some sort of overtime compensation to exempt groups. Of these, 147 pay salaried professionals—the majority of them engineers—for extra hours. It's revealing, too, that 78 of the firms pay middle management overtime, some pay top management.

As the report indicates, it's hard to generalize about the payment of overtime fees to the salaried professional. Many companies that answered the survey, and don't pay for overtime, may not actually employ such professionals. Too, engineers may be paid for inconvenience rather than for overtime—for example, when they're called in on emergency.

But, as with other exempt employees, four categories of compensation are used most by those firms that do pay extra to engineers. They are: straight time (36%), time-and-a-half (23%), two rates based on salaries (13%), and scales of payment with more than two rates, dependent on base salary (9%). In some cases (4%), equal time off is given, and in others (0.6%), a year-end bonus accounts for extra work.

Most (197) of the firms that pay overtime to exempt employees work a 40-hr. week. And of these, a majority (104) pay for hours beyond 40 hr./wk.

FEDERAL FUNDS FOR R&D

If National Science Foundation estimates are correct, the Federal government, by the end of fiscal year 1961, will have committed $9.1 billion to support national research and development activities.

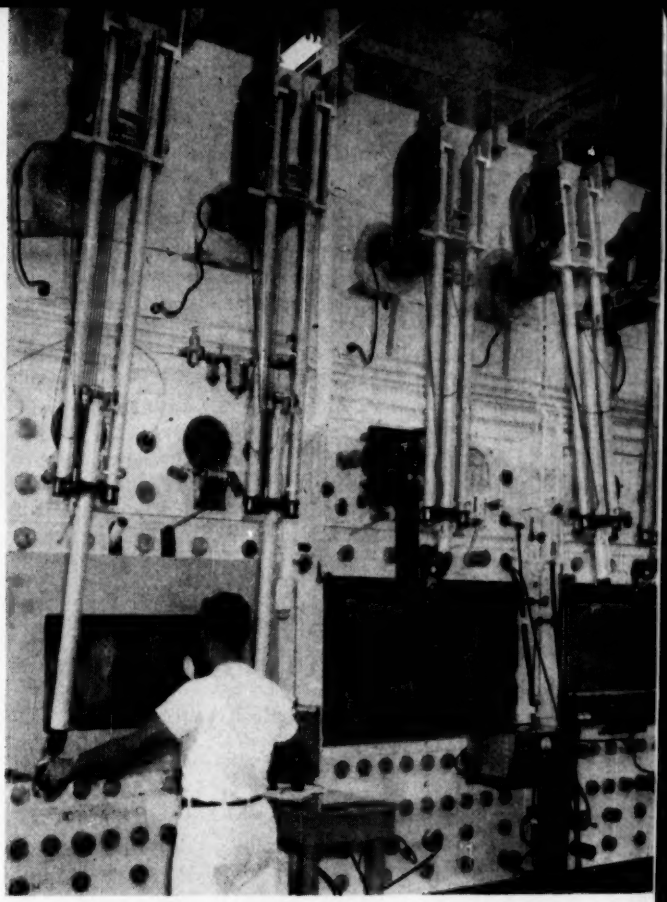
Most will have been spent for conduct of R&D—10% for "basic" research. But $600 million of the funds will have been to expand plant. Total figure is up from an estimated $8.6 billion spent in FY 1960 and an actual $7.4 billion spent in FY 1959.

These and other data on government funds for research are contained in "Federal Funds for Science, IX: The Federal Research and Development Budget, Fiscal Years 1959, 1960 and 1961." Order from: Superintendent of Documents, Washington 25, 50¢.

Design: Key to Minimizing Plant Radiation Hazards

Part 2

In design of a nuclear plant, radiation hazards must be minimized by sound engineering of shielding, remote handling, ventilation, decontamination facilities.



Master-slave manipulator permits chemical, mechanical, metallurgical operations in a "hot cell."

L. J. CHERUBIN, *Knolls Atomic Power Laboratory, General Electric Co., Schenectady, N. Y.**

Design of a nuclear reactor or a nuclear-processing plant involves problems not radically different from those of many chemical plants. However, one problem is unique in an atomic facility: radiation—and protection against it.

In our previous article (*Chem. Eng.*, June 27, 1960, pp. 105-110) we discussed radiation as a hazard, and also methods for recognizing and measuring radioactivity. We will now discuss some of the engineering factors that must be considered in design of a radiochemical plant.

Of course, one of the most effective means of controlling radiation exposure is by incorporating certain protection techniques during the design and construction of plants, facilities and equipment.

For reactors and fuel-processing plants, site location also becomes a major consideration in minimizing hazards. There must, for instance, be available: large amounts of high-purity water for cooling, impervious soil for underground liquid-waste storage tanks, a large surface stream for disposal of low-level radioactive liquid wastes, and favorable meteorological characteristics that will minimize any airborne radioactivity hazard to surrounding communities. (The AEC in Title 10, Part 50, Code of Federal Regulations entitled "Licensing of Production and Utilization Facilities" specifies construction permit requirements for any reactors to be licensed.)

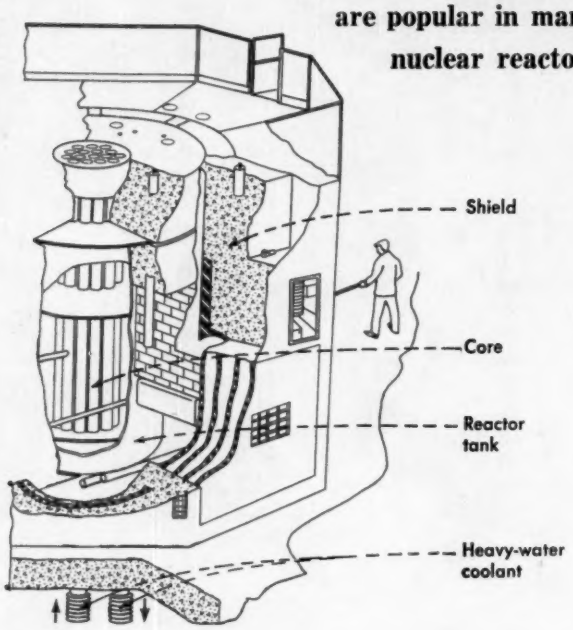
Protection Inside Radiochemical Plants

Inside plants, radiation hazard control can be maintained through a variety of methods. Many aspects of control are "built in" during plant construction. Remote operations are performed in chemical processing, reactor and critical assembly operations and certain metallurgical investigations of highly irradiated nuclear fuel. Laboratory-scale operations can be carried out in specially designed hoods and dry boxes. Machine-shop operations on radioactive materials can be handled in partially or completely hooded machines.

Adequacy of shielding and ventilation is determined by radiation surveys performed by qualified engineers or health physicists. Personnel exposure time limits are set where shielding is not completely adequate or practical to install. Respirators are worn by employees where hooding is impractical or where maintenance operations create temporary airborne contamination with radioactive materials. Body contamination can be controlled by providing a variety of garments commonly employed in industry (coveralls, laboratory coats, gloves and shoe covers; plastic or rubber gar-

* L. J. Cherubin is manager of health physics at KAPL. For his biography, see *Chem. Eng.*, June 27, 1960, p. 110.

Massive concrete shields are popular in many nuclear reactors



ments where cotton ones are inadequate, due to presence of water or acids). Where protective clothing is worn, garments are laundered in a decontamination laundry, then monitored for radioactivity before release or re-use.

We will discuss some of these techniques in detail.

Remote Handling of Materials

Chemical, physical and metallurgical operations must be handled remotely wherever multicurie levels of radioactivity are involved. High radioactivity levels are present during production of plutonium, reprocessing reactor fuel, and investigation of irradiated fuel in the so-called "hot cells." Also, critical assemblies are remotely operated as a precaution against normal radiation fields, as well as for protection against an uncontrolled reactivity incident. A common remote handling device is the master-slave manipulator used in hot cell operation. This device has been perfected to a point where remote control work can be performed with a dexterity approaching the nimbleness of the human hand.

Ventilation and Air Cleaning

Ventilation and air-cleaning requirements for operations involving radiation and radioactive materials pose both usual and special problems to the designer. Radioactive materials may be pyrophoric, volatile, solid, liquid, or gaseous; and they are generally very toxic compared with other chemicals. For example, the maximum permissible level of beryllium in air for continuous industrial exposure is 2 μg./cu. meter.; for radium-226, the limit is 3×10^{-5} μg./cu. meter. Each element is very hazardous in terms of chemical and radiological effects.

Minimum ventilation requirement for radiochemical or metallurgical laboratory operations usually is a hood with air velocities of 100-150 ft./min. at the hood opening. Dry boxes are recommended where highly toxic materials are handled (Pu-239, Sr-90, U-235) or where an inert atmosphere is necessary to prevent combustion of pyrophoric elements.

Machine-shop operations require a high velocity ventilation system to carry dust particles to separators and filters. Local exhaust ducts attached to the cutting tool are only adequate for work on low specific activity elements such as natural uranium. But for grinders and cutting wheels, complete hooding is necessary, even for natural uranium.

Usual ventilation problems include: (1) maintenance of proper air balances in supply, distribution and exhaust of the ventilation system through damper or orifice control, (2) economics of precleaning costs of supply air vs. the life of expensive exhaust-air filter, (3) economics of exhaust-air cleaning systems, (4) determination of number of air changes, (5) determination of stack height requirements, and (6) locating intake-air ducts away from any exhaust-air ducts.

Less common problems include: reducing corrosion of unfiltered air ducts and stacks to prevent fallout of radioactive particles; installation and maintenance of high efficiency filters. Filter changing must be simplified to permit speedy removal[1] (minimizing personnel exposure from accumulated radioactive material). The deposition of radioactive dust or mists in air ducts due to impaction, low velocity and rough internal surfaces can be an exposure problem and a fire-explosives hazard if the material is pyrophoric.

Typical air cleaning systems in the nuclear industry are cyclone separators, electrostatic precipitators, high-efficiency particulate filters, and a variety of chemical scrubbers and absorbers. While not essentially an air-cleaning system, in some cases it is highly desirable to have a compressor-tank storage system to hold up small volumes of radiogases whose half-life is small. Then, following activity decay, the gases can be released under controlled conditions, including monitoring, when meteorological conditions are most favorable for dilution.

Radiation Protection Facilities

Thorough radiation protection in nuclear plants requires certain facilities. Among these are: change rooms for separate storage of street clothing and plant clothing, personnel decontamination stations with personnel monitoring instrumentation, clothing and equipment decontamination facilities with radiation-monitoring equipment, area radiation-monitoring instrumentation with alarm features that alert operating personnel to unusual radiation levels due to operational mishaps caused by equipment failure or procedural errors, and plantwide emergency alarm systems

to designate emergency conditions from non-nuclear as well as nuclear accidents. Instrumentation can monitor general radiation levels, or concentrations of radioelements in the plant atmosphere, ventilation exhaust air or in water effluent released to the environment.

Disposing Radioactive Wastes

The need for treatment and disposal of nuclear-plant effluents introduces no new technical considerations to design engineers. However, in the nuclear industry, the plant designer does face some challenging problems especially in terms of safety and economy. In general, the very low level* radioactive liquid or gaseous wastes are released to the environment at the plant site (in several instances solid low-level wastes are also buried near the plant site).[3] Also, the very high level wastes, liquid* and solid, are stored permanently in underground tanks and concrete pits, respectively. The high-level air effluents are cleaned with filters, scrubbers, or both.[3]

As for intermediate levels* of wastes, ground disposal of solid and liquid wastes is practiced only at selected sites: usually, after concentration by evaporation and proper packaging, these wastes are buried at sea.[3] Combustible solids can be reduced in volume by incineration while liquids can be stripped of activity through evaporation or ion exchange so that slurry and ion-exchange units can be packaged for burial on land or sea.[3]

Shipments of large volumes of low-level radioactive waste are expensive (primarily because of packaging and shipping charges) as is shipping of small volumes of highly radioactive wastes because of heavy, thick shielding containers. Ultimate disposal areas are AEC burial grounds or the oceans.

Shielding Is Major Problem

Problems of shielding radiation are generally associated with X-ray, gamma ray and neutron radiation.

Alpha and beta rays† from natural occurring radioactive elements have a limited range in air. Biologically, external exposure to alpha radiation from radioactive elements is inconsequential because the horny layer of skin adequately absorbs this energy without harm to the underlying live tissue.

Beta radiation from natural radioelements (4 Mev. or less) can be completely absorbed by approximately 2,100 mg./sq. cm. of aluminum.

Point and beam sources of X-ray and gamma rays are weakened or attenuated by shielding material according to an exponential law of absorption: $I = B\,I_o\,e^{-\mu x}$ where B is the buildup factor, μ the attenuation coefficient of the absorber material, x the thickness of absorber material and I and I_o are resultant and initial radiation flux, respectively.

There are three principal interactions of gamma rays with matter:[4] the photoelectric effect, the Compton effect and pair formation. Photelectric effect involves complete absorption of the gamma photon energy in the production of ionization. The Compton effect is a stepwise reduction of the gamma photon energy as a result of ionization. The pair formation process involves formation of an electron and a positron that on recombination with an electron produces a characteristic gamma photon of 0.51 Mev.

Any discussion of neutron shielding becomes even more complex than that of gamma rays not only because of energy implications in the interactions, but also because neutrons can fairly readily transform stable elements to unstable elements, which in turn may emit beta and gamma radiation.

Neutrons are commonly classified according to energy[4] as thermal neutrons (below 0.2 ev.), epi thermal (0.2 to $\sim$ 10 ev.), intermediate ($<$ 1 ev. to 10^4 ev.), fast ($\sim$0.1 to 10 Mev.) and relativistic (above 10 Mev.). Neutron interaction mechanisms include[5] elastic scattering where neutron energy is transmitted to the struck atom similar to a billiard-ball effect, inelastic scattering where neutron energy is degraded and loss of neutron in energy is balanced by emission of gamma rays, neutron capture where the struck atom nucleus absorbs the neutron and the nucleus energy balance is restored by emission of a gamma photon and/or a charged nuclear particle such as alpha or a proton.

Nuclear-reactor shielding systems become complex because gamma and neutron radiation of various energies must be eliminated or reduced to low levels safe for human exposure. Problems of shield cooling as well as selecting shield materials with proper qualities to reduce costs in any industrial application challenge the design engineers.[4] A knowledge of radiation-energy quality as well as of neutron cross-sections and the gamma absorption coefficients of the shielding materials is necessary to construct both adequate and economical shielding. The subject of reactor shielding and radiation shielding in theory and practice merits very careful consideration because of its scope and complexity.

Many Shielding Materials

Most common shielding materials are concrete, water (in pits or tanks), steel or lead linings. These are used for shielding reactors and other equipment, particularly where highly radioactive materials are handled.

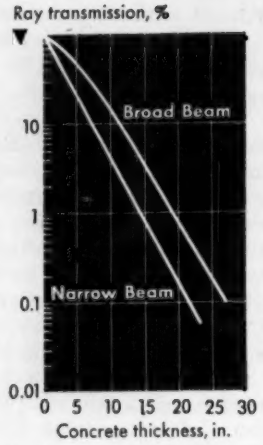
For heat removal, particularly from the inner layers of a shield, some liquid such as water or a liquid metal serves a dual purpose.

Concrete is very popular in nuclear protection because it is cheap and has a long life (see drawing,

* Low-level wastes are those whose radioactivity level is readily diluted by surface streams or atmospheric dispersal to levels safe for continuous human exposure. Intermediate-level wastes would be those that require treatment (evaporation, ion exchange, air cleaning) prior to release into the environment. High-level wastes are those which require holdup and long storage, prior to treatment and release into the environment. The nature of the radioelement and its relative radiological hazard would affect the safe level of radioactivity in water and air.

† Range in air of 5 Mev. alpha particles is approximately 3.5 cm. Range of beta rays in air is approximately 17 m.

Concrete is efficient for attenuation of radiation beams



p. 164). However, heated concrete can lose some water of crystallization, becoming less effective as a neutron shield. Lead, somewhat less popular for large shielding applications because of relatively high cost, is an excellent shield against gamma radiation, poor against neutrons.

Where shielding cost is important, material costs must be balanced against effectiveness and size of the final installation. A material with a high cost per pound may have a lower over-all cost because less of this material is required compared with, say, concrete.

In addition to gross shielding, proper radiochemical design must eliminate straight beams and annulus radiation streams through offsetting any shielding penetrations or by use of step-down plugs.

Also, scattered radiation has to be minimized through use of labyrinth entrances to reactors, critical assemblies, fuel reprocessing cells.

Important Decontamination Techniques

Cleanliness with respect to radioactive material contamination is a major challenge and preoccupation in radiochemical plants. Aside from possible immediate and long-range health hazards from external and internal irradiation—the first inkling of the serious consequences of internal intake of radioelements came from radium dial painters who shaped and wetted brush tips with their mouths—control of radioactive contamination is necessary to prevent cross-contamination of process systems, sampling systems, and radioanalytical and radiometric counting systems. In addition, sound employee and community relations demand that employees not working with radioactive materials be protected from inadvertent contamination from materials, tools, equipment, which may be transferred from radioactive materials areas of the plant for general plant use.

Many special precautions are taken in atomic-energy installations to prevent health hazards, public relations problems, or practical operating problems due to contamination of materials, equipment and facilities. Decontamination is one of the major methods used in this area. Other approaches are confining contaminated equipment, facilities and materials to controlled areas, or disposal of such items as radioactive waste.

Problems of decontamination of materials contaminated with radioactive materials are associated with tools, clothing (coveralls, lab coats, gloves, shoe covers), equipment (machine-shop equipment, pumps, tanks, vehicles, cranes), facilities (sinks, drain systems, ventilation systems including hoods, sampling systems, process streams, reactor coolant) and general items such as floors, walls, furniture, laboratory equipment (glassware, analytical balances, centrifuges, ovens).

Many Ways to Decontaminate

Many approaches are taken to eliminate or minimize decontamination requirements and loss of materials. Among them are use of:

- Protective coatings (spray coatings that can be peeled, paint, paper covers).
- Smooth surface materials that also can be readily cleaned.
- Cheap materials that are disposed of as waste after using once (paper clothing and paper liners, plastic covers).
- Tool and equipment segregation so that items that are used in radioactive materials areas are permanently stored and used in those areas only. Some degree of contamination, then, can be accepted if exposure dosage can be adequately controlled.[5]

Common decontamination techniques are:

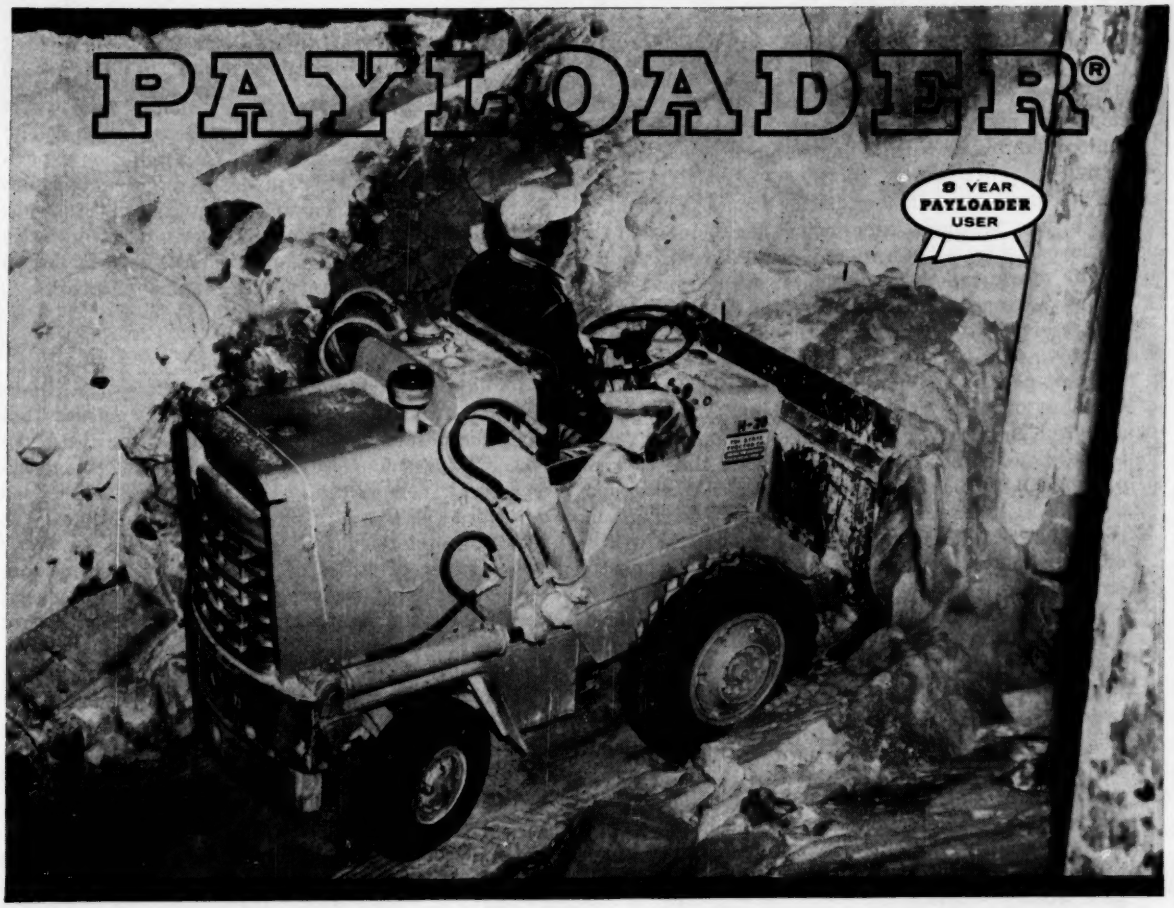
- Simple washing with soap or detergents.
- Vacuum cleaning.
- Chemical cleaning (with chemicals compatible with the contaminating chemical and the surface).
- Steam cleaning.
- Sand blasting.
- Ultrasonic devices.

Where considerable decontamination is required, decontamination facilities, equipment, supplies and procedures are incorporated in the design of the plant and in the development of operational procedures. Provision also must be made for ventilation of contaminated air and the disposal of solutions, cleaning aids such as mops, brushes, paper and cloth toweling.

It should also be noted that, in order to alert employees to presence of radiation hazards, liberal use of posted signs are made. The colors magenta and yellow have received general acceptance in this country as the code colors for radiation. Signs in these colors indicate degree and type of radio activity.

Methods for Monitoring Radiation

In addition to radiation-control techniques, various radiation monitoring instrumentation is available for measuring and recording radiation in the plant (see *Chem. Eng.*, June 27, 1960, pp. 105-110). These devices can be equipped with alarm signals (visible or audible). Widely used, also, are hand and foot radia-



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tion counters located at strategically placed points, so employees may be assured of personal freedom from radiocontaminants when going to lunch or leaving the plant.

The three important radiation-control procedures are of the personnel monitoring type. In one, the employee controls his own radiation exposure on the job by measuring the radiation levels to which he is actually exposed and calculating the total dosage he has received by factoring in the actual time of exposure in his computation. The other general procedures feature measurement of external radiation exposure over an extended period of time (week to a month) by means of a film badge, and internal radiation exposure over an extended period of time (a week or longer) by bioassay to determine body accumulations of radioelements. It is customary to maintain records of radiation exposure of employees as well as of radiation measurements made in the course of environmental and in-plant radiation surveys.

It is obvious that in all this effort the skill, care and effort of the employees are required, and this radiation health aspect demands that the employee be well versed as to radiation hazards and protective measures to cope with them. On-the-job training, special instructions in radiation monitoring, carefully prepared operating procedures, radiological safety meetings and a variety of communication media are employed to inform and alert personnel about sound radiation protection practices.

Community Problems

Community considerations are generally associated with release of radioactive liquid wastes into surface streams, with release of stack-air effluents containing radioactive material, and with shipment of radioactive materials.

As an audit of radioactive waste disposal practices, it is common to sample surface stream waters, plant environmental air, soil and vegetation, and test these samples for radioactivity. Plant environmental monitoring will also generally involve measurement of general radiation levels to establish the level of external radiation present.

State Advisory Committees

To keep state health departments informed of AEC operations as they affect the public health, and to develop and maintain sound public relations, several AEC operations offices have established state advisory committees composed primarily of state health department representatives. The states of New York, Washington, and Georgia have such advisory committees. They are the Mohawk River Advisory Committee, Savannah River Advisory Committee and Columbia River Advisory Committee. In addition, AEC-State liaison is maintained through regional groups—for instance, the New York-New England Water Pollution Control Committee and the Ohio River Valley Pollution Control Authority.

The state advisory groups offer mutual advantages to the AEC and state officials concerned with public health. There is a blending of AEC radiation experience with the long and broad experience of state health representatives on non-nuclear sanitation problems. In the Knolls Atomic Power Laboratory's work with the Mohawk River Advisory Committee, such liaison activities have been very fruitful and effective.

More Data Needed

While a few serious injuries including death have occurred from radiation, it is generally agreed that radiation hazard has been well controlled in the development of atomic energy.[6] In the course of this development, a new health protection activity has been developed called health physics, sometimes known as radiation protection.

The range of duties of a health physicist includes review of facility designs and operational procedures, development and implementation of radiation hazard control programs, development and evaluation of radiometric methods and procedures, formulation of radiological-safety standards, and the assessment of radiation-hazard potentials. In many instances, the health physics functions are extended to include radiological operations such as radioactive waste disposal and direction of the decontamination laundry operations.

The health physics manpower requirements at a major atomic energy plant may range from a fraction of 1% to as high as 6% of the plant population where responsibilities include radiological operations, research and development, and where around-the-clock operations are carried on. The future challenge in radiation protection lies in clarifying the threshold biological effects of radiation and the establishment of firm, safe limits, in developing increased knowledge about the natural environment and its ability to accept radioactive wastes, in facility design improvements that further minimize the need for operation control of radiation hazards, in reduction of operational radiation control costs through improved radiometric systems and in the extension of knowledge on radiation hazards and their control to all employees.

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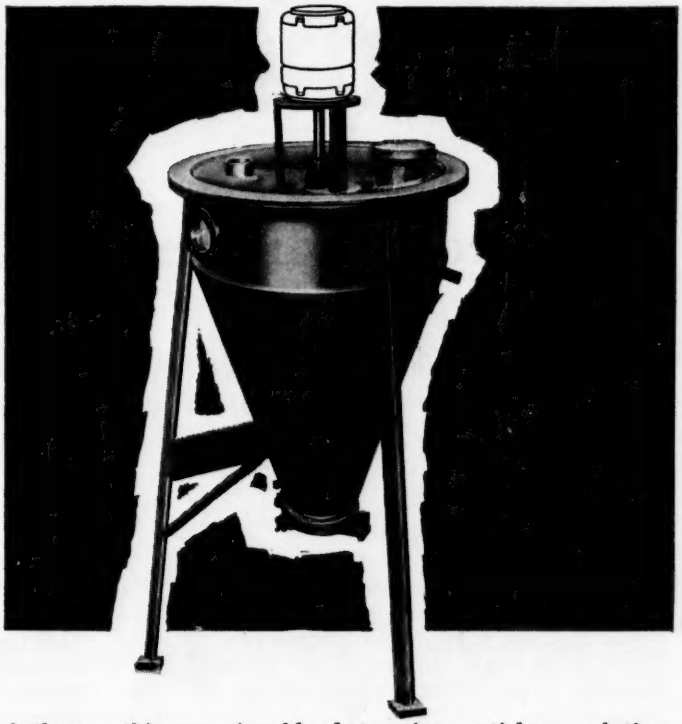

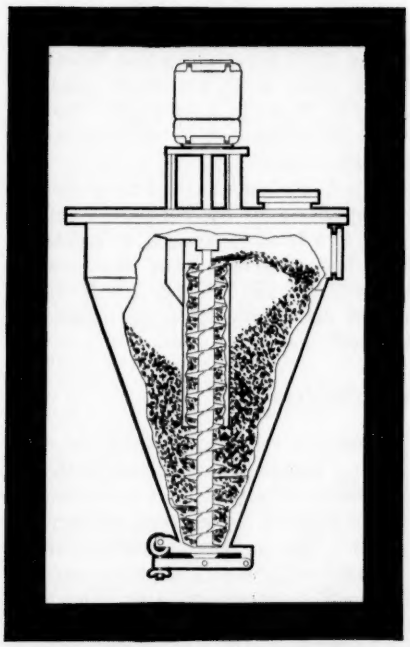

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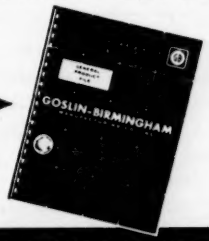

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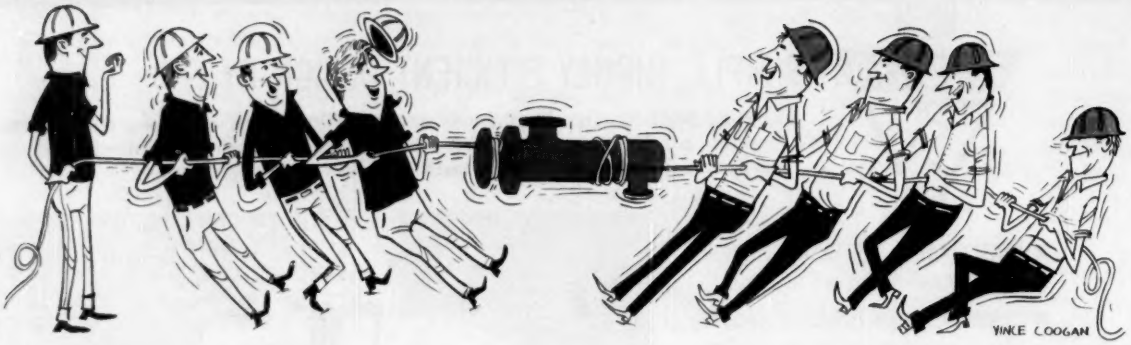

Contract Maintenance–How Far to Go?

Three refinery maintenance men give their views on outside contracting. One advocates complete contracting of maintenance and plant engineering—the others see it as a valuable supplement to regular in-plant maintenance forces.

The trend in petroleum refineries is to more and more outside contracting of maintenance work. In established facilities, however, the company has a responsibility to its employees, and to the community, that prevents it from taking full advantage of this method of operation.

These were the general conclusions reached during a session at the recent Plant Maintenance and Engineering Show in Chicago.

R. B. Beattie described Tidewater Oil's new 140,000-bpd. refinery at Delaware City. This facility, which was specially designed for complete contract maintenance, has 11 major units. These include a 102,000-bpd. cat cracker, an 88,000,000-cfpd. gas plant, 140,000-bpd. crude unit, 5,000-bpd. alky plant, 16,000-bpd. polymerization plant and a 150-tpd. sulfur plant.

Humble Oil's W. W. Harris described his company's 300,000-bpd. Baytown refinery. Products of the refinery, which occupies 2,500 acres along the Houston Ship Channel, include fuels, lubes, petroleum specialties and petrochemicals. There is a permanent maintenance force that is supplemented by contract personnel during peak work loads.

Phillips Petroleum's A. P. Olbrich coordinates maintenance activities for all six of his company's refineries. These range in size from 95,000 bpd. at Sweeny, Tex., down to 3,800 bpd. at Great Falls, Mont., and have a combined capacity of 275,000 bpd. All of them depend on permanent plant forces for maintenance, with supplementary outside help.

This article is based on a discussion held at the 12th Plant Maintenance and Engineering Show in Chicago this January. Topic for discussion was "The Pros and Cons of Outside Contracting." Speaking pro: R. B. Beattie, supt. of engineering, maintenance and construction at Tidewater Oil Co.'s Delaware City, Del., refinery. Speaking con: W. W. Harris, ass't. supt. of maintenance and construction at Humble Oil and Refining Co.'s Baytown, Tex. refinery and A. P. Olbrich, chief maintenance consultant for Phillips Petroleum Co.—ED.

What Is Contract Maintenance?

At Tidewater's Delaware refinery, contract maintenance is "a service that supplies the customer with an adequately skilled labor pool, experienced supervision, engineering facilities and any other type of service the refiner may need." This service is distinguished from the "labor broker" who merely supplies men to work under his clients' supervision, and from the contractor who supplements existing maintenance forces for short periods.

The last definition more closely describes the situation at Humble and Phillips. Here, contract maintenance refers to the letting of a contract to perform only a specific, well-defined item of work on a one-time basis for a given fee.

The Tidewater refinery, because of labor difficul-

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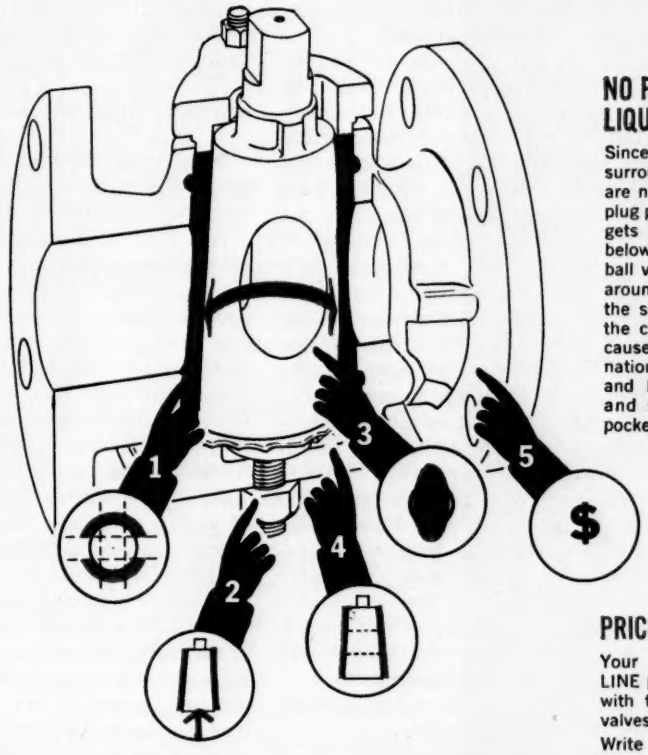

4.

NO POCKET TO COLLECT LIQUIDS AND SOLIDS

Since the SLEEVELINE plug is surrounded by Teflon, there are no pockets into which the plug ports can drain. No Liquid gets to the body around or below the plug. The ports in ball valves drain into a pocket around the ball and between the seals when the ball is in the closed position. This can cause process fluid contamination; corrosion of the body and ball by stagnant liquid; and solids build-up in the pocket, creating seal failures.

5.

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Your comparison of SLEEVELINE prices and performances with those of other types of valves is also suggested.

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½"	0.196	0.150	77	0.196	100
¾"	0.442	0.248	56	0.441	100
1"	0.785	0.518	66	0.785	100
1½"	1.767	1.227	69	1.150	65
2"	3.142	1.767	56	1.960	63
3"	7.068	4.430	63	3.800	54
4"	12.566	7.669	61	7.100	56
6"	28.274	15.465	55	17.000	60

Flow capacity is sometimes cited as a selling feature for ball valves. Compare some typical ball valve port openings with those of DURCO SLEEVELINE valves.

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ties experienced at another of the company's locations, was designed specially for complete contracting of maintenance and plant engineering services.

Since Sept. 1956, the contract maintenance work force has fluctuated between 150 and 924 men. The contractor has supplied field supervision for both normal and peak loads, engineering draftsmen, structural designers, process engineers, estimators, clerical assistants, engineering buyers and turnaround inspectors. The main contractor is the Catalytic Construction Co., and there have been a host of smaller contractors.

The refinery is divided into three maintenance areas. Each area is manned by a zone coordinator and an assistant who are Tidewater employees. Also in each zone are a superintendent and planner, working for the contractor. The company's zone coordinator is the final and absolute authority in his zone. This, according to Beattie, is the only way in which complete contract maintenance can be expected to work.

At first, Tidewater insisted that one of its men co-supervise all of the contractor's work. Over four years of operation, however, the line between the company and the contractor's supervision has become fainter because of a mutual desire to do a good job.

All the contractor supervisors and planners have had previous refinery experience and now it is not uncommon for a contractor's man to be in charge of an in-plant construction project or a complete shift on a large unit turnaround. Conversely, a Tidewater man may be in charge of a group of contractor's men.

The actual planning and scheduling is done by the contractor's employees under the supervision of the Tidewater coordinator or his assistant. In a difference of opinion, the employer's decision is final, but the contractor is encouraged to offer an opinion, make a suggestion or question a decision at any time.

At the Humble refinery, in contrast, there are 1,800 permanent company employees in the Maintenance and Construction Division, which is directly accountable to the plant manager. These men are highly skilled, long-service personnel who are thoroughly familiar with the maintenance techniques and operating equipment in the refinery. They perform not only maintenance work but also capital construction.

Contract maintenance is used to perform three broad classifications of work. These are:

- Work requiring special equipment or techniques where frequency of use does not justify the company owning the equipment or hiring the skills. Examples: dredging harbors and building levees, chemical cleaning of equipment, steeple jacking, asphalt paving and erection of very tall or heavy equipment.
- Work for which the skill of the specialist is required on a routine basis and which is readily available in the market on a competitive basis. Examples: checking weigh scales, strapping tanks, inspecting elevators, installing and maintaining sprinkler systems, maintaining air-conditioning systems, installing and repairing refractory materials, cleaning storage tanks by vacuum truck and rewinding electric motors.
- Work required in spot situations during peak work loads and in cases where a particular craft skill is in short supply. Examples: storage tank repair, cooling tower repair when the work is extensive and seasonal, boilermaking and rigging on major unit turnarounds, painting when the annual requirement is greater than can be performed by refinery personnel, installing and maintaining electric power lines.

During 1960, contract maintenance at the Baytown refinery amounted to about 10% of the total.

A similar maintenance system exists at the six Phillips refineries. Normal maintenance and some new construction are handled by plant forces, with supplementary work being done by outside contractors. There are approximately 800 hourly maintenance personnel in the six plants, exclusive of clerical help. The contract work amounts to about 5-7% of the total.

Contract work primarily supplements the regular forces on some of the cat cracker turnarounds, major painting, road repair, major tank repair, chemical weed control, chemical cleaning and similar jobs. New unit installations are also done by contract.

Handling Fluctuations in the Work Load

With total contract maintenance, Tidewater can ignore the problem of fluctuating manpower requirements that plagues the conventional maintenance man.

Mr. Beattie described a situation when the cat cracker was shut down, followed two weeks later by the gas plant, the crude unit, the alky plant, the poly plant and the sulfur plant. The contractor's manpower rose from a preshutdown level of 181 men to 480 men at the end of the first week, to 900 men seven days later, and to 924 men the following week. One week after this peak, the manpower was down to 375, and seven days later back to the preshutdown level of 181. All units were on line within four weeks.

At no time during this period was there a shortage of skilled manpower in the needed crafts. The contractor supplied additional field supervision from other projects throughout the country.

A large number of craftsmen are available to Tidewater during periods such as this because the work is normally done in two 10-hr. shifts six days per week with key jobs continuing on the seventh day. The overtime premium has been enough inducement for men to abandon current jobs and preferentially seek employment with Tidewater's contractor.

At Phillips and Humble, on the other hand, careful planning and scheduling are required to minimize the effect of fluctuating demand on the permanent forces.

Operating unit shutdowns are scheduled a year in advance. This long range turnaround schedule (in spite of inevitable reshuffling) coupled with a backlog of routine and preventive maintenance and construction provides the flexibility for a balanced load.

Phillips tries to maintain a four-week backlog on an over-all basis, with two to three weeks for some specific skills such as instrument mechanics and electricians—in lesser-skilled trades, five to six weeks.

Improvements in refinery technology, which have led to larger plants with fewer processing units, have caused new headaches for the scheduler. Refinery

turnarounds now are larger and more widely spaced, and the peaks and valleys in the work load are, therefore, more marked than they used to be. Because of this, the trend has been toward more contracting of maintenance work for such jobs as cat-cracker turnarounds and others previously listed.

Both Humble and Phillips have adopted capital construction as one method for keeping their permanent employees occupied during lows in the maintenance work load. At Humble, the permanent work force is so large that some capital construction can and does continue during peak maintenance work loads. This is also attributable, says Humble Oil's Harris, to the changing nature of the trade skills needed from one peak to another. Last year, Humble used about 330 men per day from its permanent forces for construction, supplemented by about 200 contract men.

In Phillips' refineries, the maintenance personnel also serve as a pool for vacancies in the plant. They perform operator relief for any absences and vacations beyond the capacity of the operating personnel. During the summer, when vacation peaks occur, additional help is hired, usually college students.

The Attitude of the Unions

Tidewater is also relieved from dealing with the various trade unions. All this is handled by the contractor who has negotiated agreements with 14 building trade unions on an international basis. The contractor's representative meets each month in Washington with the international union officers to review and resolve all problems from the previous month.

In the plant, the contractor's project superintendent meets weekly with the shop stewards to discuss in-plant problems such as safety, working conditions and contemplated work load. Since union policies or politics are not discussed, most suggestions or complaints can be handled immediately.

The employer has no direct dealings with the unions at all, although of course he is consulted by the contractor before money is expended for any equipment or changes requested by the stewards. Although Tidewater has no voice in future negotiations between the contractor and the building trades, any settlement will conform to the national standard.

This arrangement is favored by the AFL-CIO, Tidewater's Beattie said, not only because of the negotiations on a national scale, but also because the reliability of jobs at Tidewater gives a degree of permanence and security to men who would otherwise be following jobs around the country. No labor disputes have arisen during the four years and 26 turnarounds that the plan has been in effect.

Phillips' Olbrich pointed out that union problems do arise in plants that make limited use of contract maintenance. If the employer has a contract with an authorized bargaining unit, a clause is usually included in which the company agrees that it will not contract normal routine maintenance work within the refinery as long as the refinery has the necessary men and equipment available to properly perform such work. This imposes a limitation on some contract work but still gives leeway to contract highly specialized work and jobs with peak manpower requirements.

Another problem in partial contracting is the misunderstanding that sometime arises from the mixing of industrial and craft unions. Usually the working practices, rates of pay and job conditions are different. These problems can be overcome by segregating the two groups as much as possible; and on major unit turnarounds, this is not too difficult.

Do Contract Men Have the Needed Skills?

Under complete contract maintenance, the employer and the contractor are the sole judges of whether a man is sufficiently competent to do his job. If he is not, he is not kept on. It is much easier to do this with contract maintenance than with company employees.

At first, Tidewater had the problem of training and adapting the building trade men to refinery maintenance work. This problem was overcome with time because during peak loads the more or less stable work force takes over much of the line supervision, on-the-job training and indoctrination of the newer men. Most of the trade personnel in the area have worked in the plant on turnarounds and construction projects several times and are fairly familiar with the equipment, procedures and working conditions.

Tidewater provides no training for maintenance because the union supplies only skilled men and has its own apprenticeship programs. The company does give courses in petroleum processing, welding and blueprint reading, which are open to the contractor's personnel, who make liberal use of them.

When a company has a permanent maintenance force, it is normal to have continual training programs for the various crafts. The firm thus has a group of highly skilled men who are thoroughly familiar with the plant and its equipment and are loyal employees.

Contractors, called in on an intermittent basis, supposedly have an unlimited field of skilled men from which to choose. These men, however, are generally construction workers who are not familiar with maintenance techniques and who must learn from on-the-job experience. Also, each piece of equipment, particularly instruments, requires more skill than just a basic knowledge. In his experience, Olbrich said, contractor's craftsmen, particularly on instruments, pumps and compressors, have not shown a high degree of skill or proficiency.

If the employer is to allow for on-the-job training of contractor's men, he stands to spend a great deal of time, money and downtime, and then lose the man to another phase of the contractor's activities.

How Do Costs Compare?

Under complete contract maintenance, the cost is usually that to the contractor for all personnel on the jobsite—craftsmen, field staff supervision and engineers—plus a negotiated percentage for overhead and profit. This percentage varies depending on the

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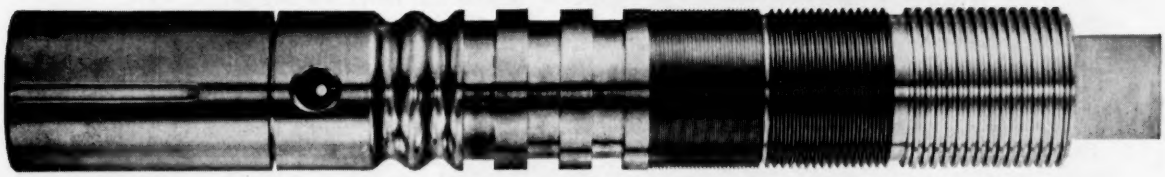

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work volume, and increments occur on a sliding scale; as the volume increases, the fee decreases.

Although hourly rates for contract labor are higher than for in-plant personnel, Beattie believes that total man-hour costs are less for a contract when account is taken of all fringe benefits and basic rate increases for permanent personnel. These costs arise from: idle time, make work, more overtime, longer downtime, lower productivity and increased investment for restaurants, change houses and recreational facilities.

In the petroleum industry, fringe benefits run around 23-25% of wages. Although some of these costs are passed along to the customer by the contractor, Tidewater has found that the passed-on costs are only about 10%.

In Olbrich's view, the contractor's comprehensive hourly rate is higher than the rate for plant personnel and, for complete contracting to be considered, the contractor would have to do a more effective job of manpower utilization than the refinery. In Phillips' experience, the contrary has proved to be true.

Olbrich also pointed out the costs of duplicating supervision that occurs with complete contract maintenance. The contractor requires a basic staff organization to properly carry out his functions, and the plant will likewise have supervisors to coordinate the work of the contractor.

Humble has also found its costs to be at most equal to a contractor's under the same conditions. Harris admitted, however, that there was a question whether proper overhead costs had been included in the comparisons. He felt that in the final analysis the cost differential is in the in-plant organization's efficiency and productivity versus those of the contractor.

Both Humble and Phillips have found that their maintenance costs and payroll size have decreased in recent years because of increased efficiency, increased productivity, leveling of manpower peaks and valleys with capital construction and judicious use of contracts.

A Difference in Degree Only

Beattie summed up Tidewater's case for complete contract maintenance by saying that the greatest advantage of the plan is its extreme flexibility. The work force is tailored to fit the work load and no make work as needed to keep the force busy. If the work load drops off, the contractor can terminate any portion of his force on two hours' notice, although in practice it does not fluctuate greatly from day to day.

Beattie answered the frequent charge that there is no "esprit de corps" in a contract work force by pointing out that in his work force: absenteeism is below 3%, constructive suggestions are constantly volunteered, craft lines are lowered in case of emergency, mechanics and process people work in harmony, action is aimed to lower costs and increased efficiency.

He added that Tidewater has complete faith in its contractor, whose longevity in the refinery is based solely on performance.

Finally, he pointed out two factors that must exist to make complete contract maintenance a success. These are:

1. The employer must insist upon having a representative with complete and final authority over the contractor.

2. The plant must be located in an area where there is a large skilled work force available.

Harris closed by listing what he considered to be the advantages and disadvantages of contract maintenance. The advantages:

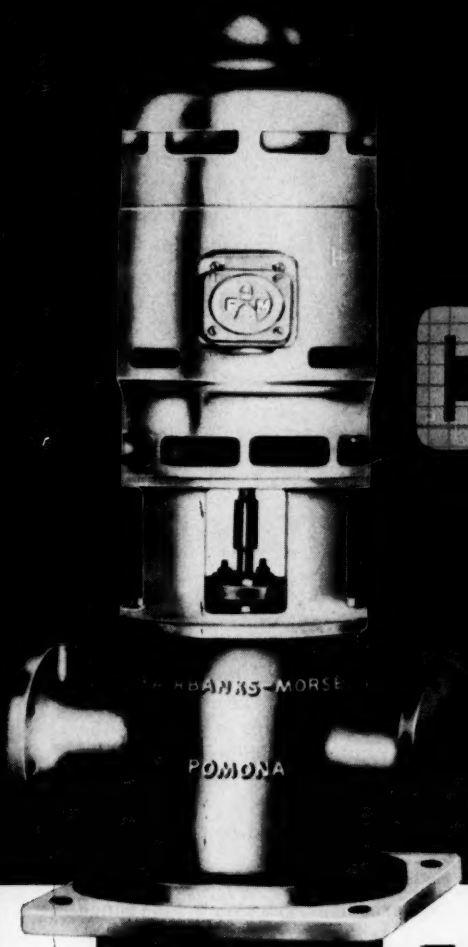
- The employer need not purchase and maintain expensive specialized equipment.
- He can hire special skills and routine services available in the market on a competitive basis.
- He can meet peak work loads without hiring and firing permanent forces.
- He need not hire additional supervisory and clerical employees for incremental work loads.
- He can perform capital construction projects with his own forces on a selective basis. This is important where new equipment is tied into existing equipment or where secrecy is involved.

Harris listed these disadvantages:

- Contract employees are not as skilled as plant forces, particularly in such crafts as instrument mechanics. Usually, the men available are construction workers.
- Contract workers and supervisors are unfamiliar with plant practices.
- Maintenance jobs are almost never clear cut and contracts must be cost plus, with no competitive bids.
- Contractors do not feel the same pressure to meet deadlines as do plant forces.
- More detailed specifications must be furnished to contract forces.
- Misunderstanding is apt to arise between contract men and plant men. Also, contractors' labor problems can affect job completion.
- It is difficult to contract instrument and electrical work because skilled men are not available.
- Contract maintenance availability depends on the job situation in the area.
- It is difficult to get three-shift coverage without paying overtime.
- Contract forces are not as flexible as plant forces who can be sent to other areas if needed.

Both Olbrich and Harris agreed that some contracting of maintenance is necessary and desirable. Olbrich also said that if he were participating in the design of a new plant, he would give serious consideration to a complete contract maintenance system, as described by Beattie. He reiterated, however, that an established plant has a responsibility to its community that prevents a wholesale changeover to complete contract maintenance, with the disruption of company employees that would result.

Some points of the foregoing discussion are peculiar to petroleum refining, which has large-scale, predictable turnarounds. In general, however, the conclusions and opinions expressed will serve as guides for any chemical-process plant where contract maintenance is under consideration.



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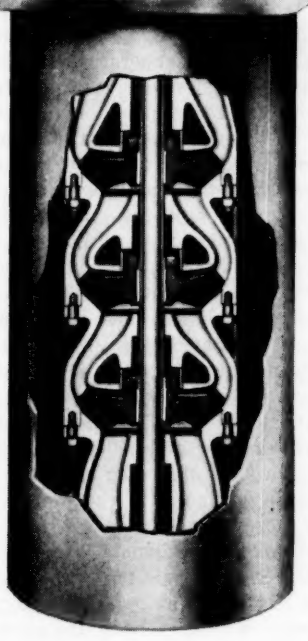

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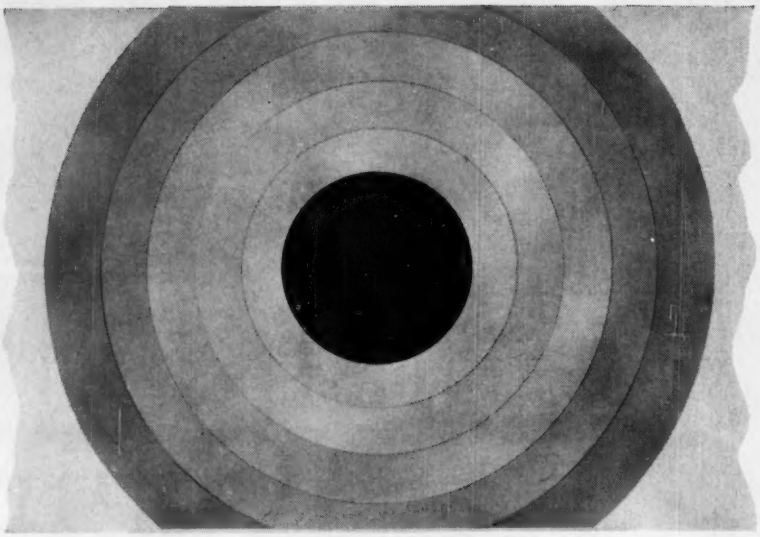
Minuscule amounts of platinum or palladium prevent embrittlement of tantalum in aqueous media. Small spot of noble metal affixed to tantalum surface extends influence over relatively vast area.



Protect Tantalum From Hydrogen Embrittlement

A small quantity of platinum metal, welded, riveted or electrodeposited on tantalum, markedly inhibits hydrogen embrittlement of the tantalum. This is the finding of two Union Carbide researchers, Claude R. Bishop and Milton Stern, detailed in a paper given at a recent Buffalo meeting of the National Assn. of Corrosion Engineers.*

Table I shows the remarkably small areas of noble metal that are required to protect large areas of tantalum from embrittlement.

Hydrogen embrittlement in aqueous media has long been a prime cause of failure of tantalum equipment. This is probably not due to any particular susceptibility of tantalum to this defect, but because the metal is so often used in exceedingly aggressive environments; tantalum is well known to be one of the most corrosion resistant of metals.

▶**Where It Occurs** — Of course, not all such environments cause hydrogen embrittlement. For example, tantalum will not undergo hydrogen damage in boiling hydrochloric acid, no matter what the acid concentration. However, high concentration of HCl will cause embrittlement if the temperature is raised to 190 C. Embrittlement also occurs in sulfuric acid of more than 85% concentration, which boils at about 230 C.

The trend in the chemical process industries toward higher and higher operating temperatures will likely put more tantalum into environments where hydrogen embrittlement is more likely to occur.

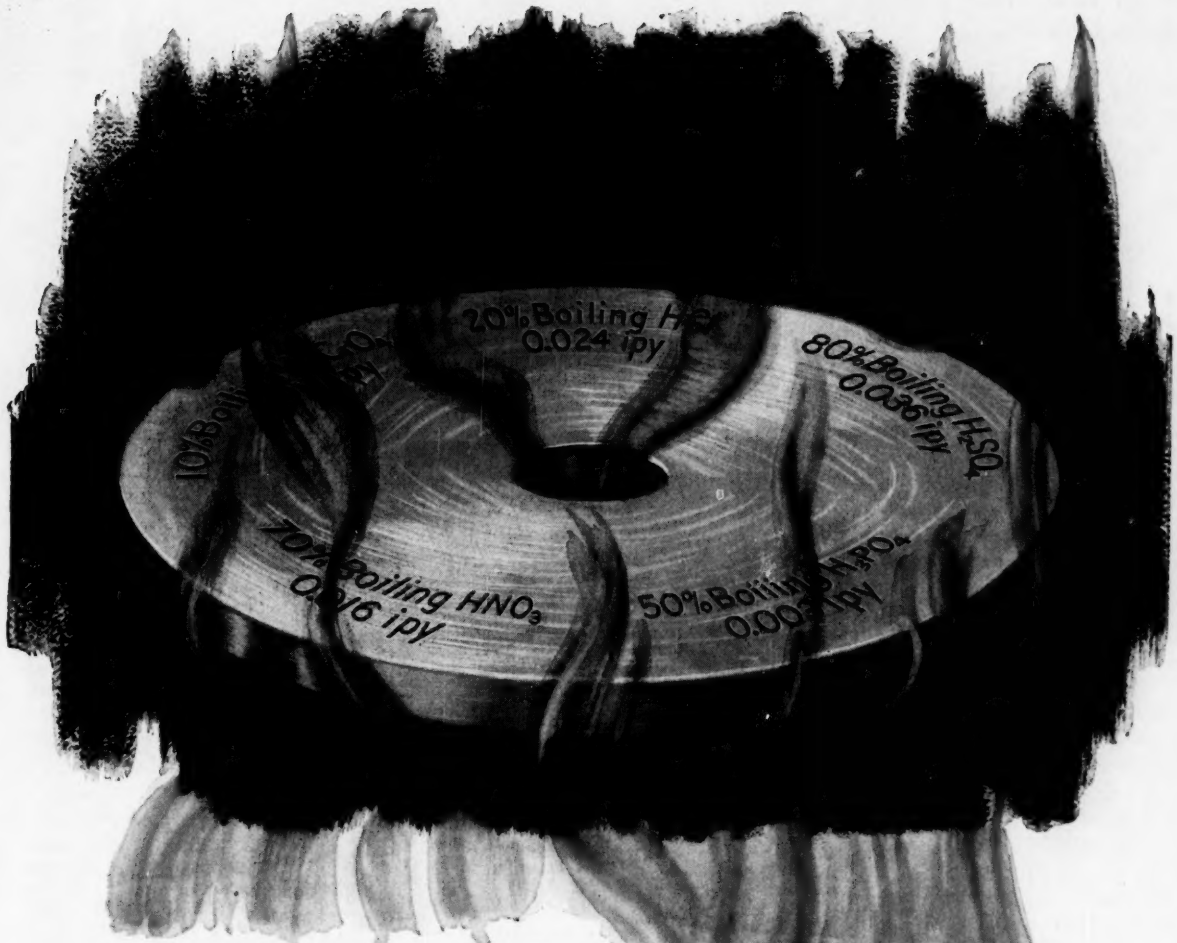
The exact process by which hydrogen embrittles tantalum is not understood. One theory is that absorption of hydrogen expands the metal lattice, causing stresses that result in embrittlement. It is known that cold-working the metal makes it more susceptible to hydrogen damage.

▶**Absorbs Hydrogen** — Tantalum absorbs hydrogen over a wide range of temperatures; embrittlement may occur merely by deforming the metal at room temperature in the presence of gaseous hydrogen. In a corrosive environment, hydrogen may be formed directly on the tantalum surface by the corrosion processes. Or, it may be evolved by galvanic action if the tantalum is coupled to some more active metal. Process equipment may be protected from this condition by electrically insulating the tantalum parts from other metals. Of course, insulation has no effect if the hydrogen is generated by corrosion.

Embrittled tantalum may often be restored to a ductile condition by a vacuum annealing operation.

However, finding a vacuum furnace large enough to take a fabricated piece of equipment is another story. Protection from embrittlement in the first place is a far more desirable way of solving the prob-

* NACE Meeting, Hotel Statler, Buffalo, New York, Mar. 14-16, 1961.



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lem. Attempts by researchers Bishop and Stern to prevent hydrogen damage by heat treatment or by alloying with small amounts of such materials as oxygen, carbon, iron, silicon, nickel, columbium, titanium or tungsten, were all unsuccessful and showed no promise of improvement by any further work in that direction.

▶**Prevent Hydrogen Damage** — However, efforts to prevent hydrogen from entering the tantalum by means of a surface treatment were successful. The method employed was to connect the tantalum to another element that had a low hydrogen overvoltage and that was electrochemically cathodic to the tantalum in the same environment. The platinum group metals were found to be ideal for this purpose. Remarkably small areas of platinum, palladium, gold, iridium, rhodium, osmium, ruthenium and rhenium were effective. A small spot of any of these metals could be welded, riveted or electrodeposited on the tantalum. Merely rubbing the tantalum surface with one of these metals was found to be an effective means of deposition.

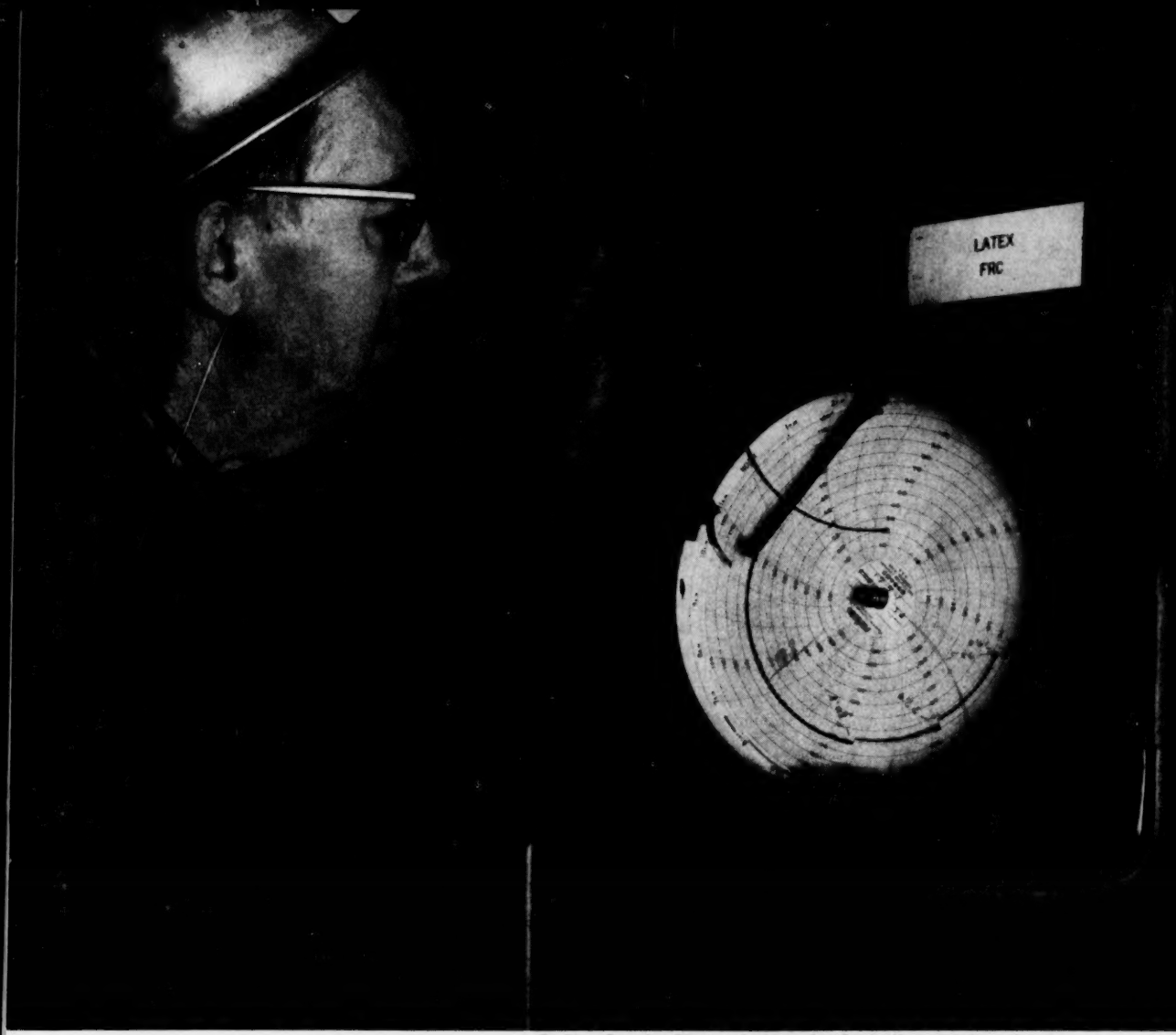
Platinum and palladium are of particular interest because of their innate corrosion resistance. Although palladium is less resistant than platinum, it does have the advantage of being cheaper.

In the table, effect of platinum and palladium in preventing hydrogen embrittlement of tantalum in hot hydrochloric acid is shown. Oddly, though platinum and palladium corrode rapidly when in hot HCl, the corrosion rate is negligible when they are in contact with tantalum. The tantalum and platinum are both helped by galvanic contact.

▶**Tantalum Plugs**—Although the use of tantalum equipment is not very widespread, many chemical plants use small tantalum plugs for patching holes in glass-lined vessels. Since the plugs are in contact with the steel shell of the vessel, any additional break in the glass lining causes a galvanic couple, which may lead to embrittlement of the plug. A small area of platinum on the plug will prevent such embrittlement.

Tantalum Condition	Thickness, In.	Temp., °C	Noble Metal Used	Approx. Area Ta:Noble metal	Test Period Hr.	Corr. Rate, Mpy.	Result of Bending Test
Platinum and palladium with tantalum in hot hydrochloric acid							
As-cold-rolled	0.01	190	None	.....	183	12	Brittle
			None	.....	283	..	Brittle
			Pt	15:1	283	3	Ductile
			Pt	31:1	319	4	Ductile
			Pt	3,180:1	319	4	Ductile
			Pt	3,180:1	329	4	Ductile
			Pd	15:1	238	4	Ductile
			Pd	31:1	319	4	Ductile
			Pd	3,180:1	319	5	Brittle
			Pd	3,180:1	329	4	Brittle
Annealed after cold rolling	0.01	190	None	.....	371	10	Brittle
			None	.....	371	6	Brittle
			Pt	1,590:1	371	5	Ductile
			Pt	3,180:1	371	4	Ductile
			Pd	1,590:1	371	5	Brittle
			Pd	3,180:1	462	4	Ductile
Commercial sheet as received	0.02	190	None	.....	139	15	Brittle
			None	.....	183	13	Brittle
			Pt	31:1	319	4	Ductile
			Pt	3,180:1	319	4	Ductile
			Pt	9,560:1	139	4	Ductile
			Pd	31:1	319	4	Ductile
			Pd	3,180:1	319	4	Ductile
			Pd	9,560:1	304	4	Ductile
Commercial sheet as received	0.03	190	None	.....	133	9	Brittle
			None	.....	258	6	Brittle
			Pt	4,780:1	535	6	Ductile
			Pt	4,780:1	535	5	Ductile
			Pt	9,560:1	1,004	4	Ductile
			Pt	9,560:1	1,004	4	Ductile
As-cold-rolled	0.01	250	None	.....	183	..	Brittle
			Pt	31:1	346	20	Ductile
			Pt	3,180:1	346	23	Ductile
			Pd	31:1	346	21	Ductile
			Pd	3,180:1	346	22	Brittle
Commercial sheet as received	0.02	250	None	.....	183	..	Brittle
			Pt	31:1	346	30	Ductile
			Pt	3,180:1	346	23	Ductile
			Pd	31:1	346	21	Ductile
			Pd	3,180:1	346	18–36	Brittle
Commercial sheet as received	0.03	250	None	.....	90	39	Brittle
			None	.....	219	..	Brittle
			Pt	1,590:1	164	41	Ductile
			Pt	4,780:1	90	30	Ductile
			Pt	9,560:1	219	22	Ductile
			Pd	1,590:1	164	29	Brittle
Platinum and palladium with tantalum in boiling sulfuric acid							
Commercial sheet cold-rolled	0.01	238	None	.....	371	15	Brittle
			Pt	1,590:1	371	4	Ductile
			None	.....	557	12	Brittle
			Pt	1,590:1	557	5	Ductile
			None	.....	371	15	Brittle
			Pd	1,590:1	161	5	Ductile*
			Pd	*.....	210	13	Brittle*
Commercial sheet as received	0.03	238	None	.....	371	8	Ductile
			Pt	1,590:1	371	4	Ductile

* Palladium spot dissolved during first 161-hr. test period.



Foxboro Dynalog Electronic Recorder/Controller holds latex flow at exact preset value. Installation: Copolymer Rubber and Chemical Corp., Baton Rouge.

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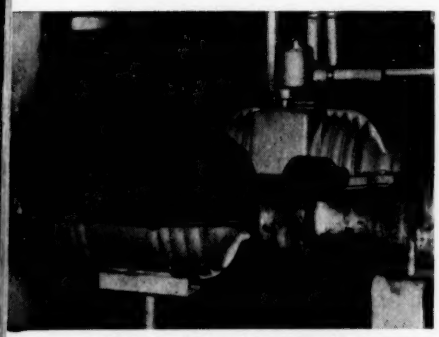

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POLYESTERS AREN'T ALL SUITED FOR CORROSIVE MEDIA

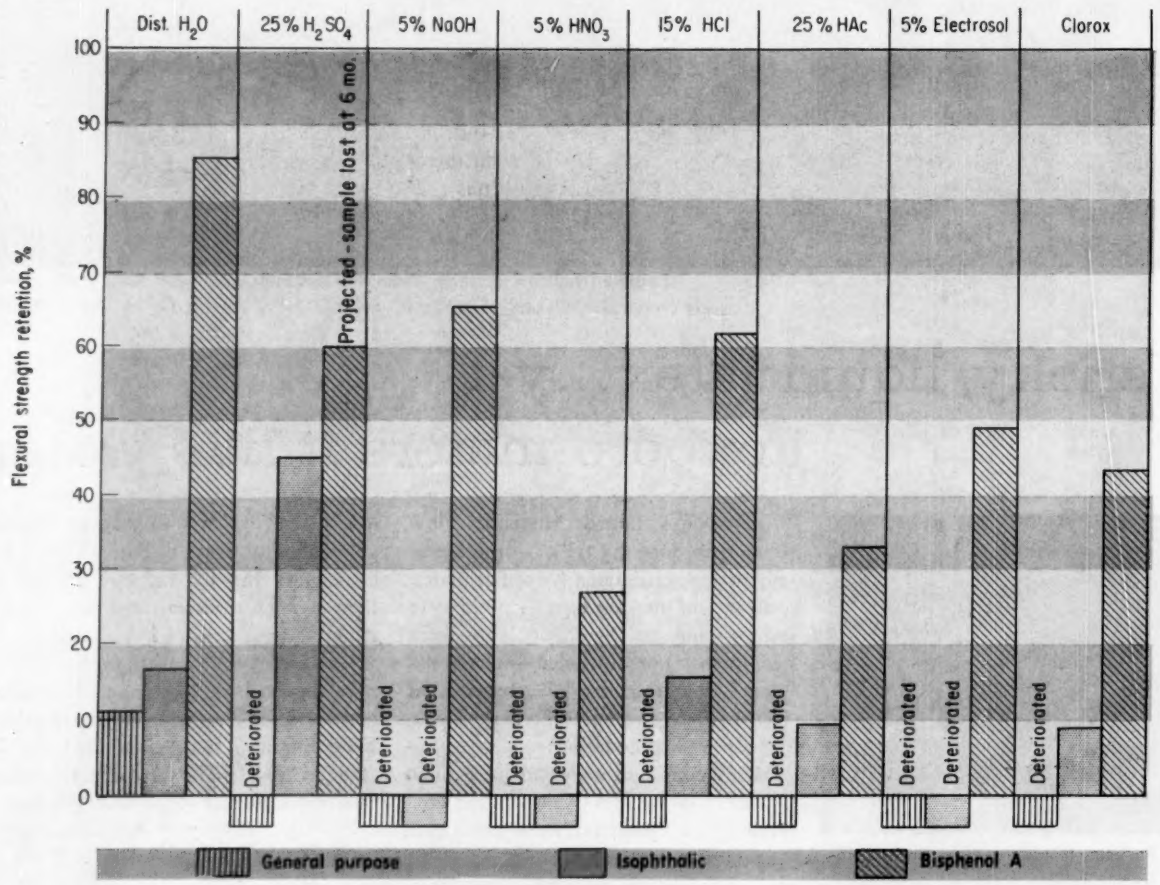
Plan to use a polyester in corrosive service? Resistance varies widely according to the specific type of resin. Here's information you want for intelligent selection of a polyester resin to suit your needs.

Corrosion resistance of various types of commercial polyesters differed widely in tests recently reported by A. F. Torres and S. S. Feuer of Atlas Powder Co. in a paper given at the 16th Annual Conference of the Reinforced Plastics Division, Society of the Plastics Industry, in Chicago.

▶**Resins Tested**—Three types of polyester resins, bisphenol A, isophthalic and general purpose, were made up into castings and tested for one year in eight different corrosive solutions. The corrosive agents, held at a temperature of 210 F., were distilled water, 5% sodium hydroxide, 5% nitric acid, 25% sulfuric acid, 25% acetic acid, Clorox (5.25% sodium hypochlorite) and 5% Electrosol (an alkaline dishwashing detergent).

The general-purpose polyester, prepared from propylene glycol, maleic anhydride and phthalic acid, obviously was not suited for corrosive service. It deteriorated in from one to six months in all the test solutions except distilled water. The isophthalic polyester did somewhat better, surviving the distilled water, sulfuric acid, hydrochloric acid and Clorox tests. However, this plastic, prepared from propylene glycol, maleic anhydride and isophthalic acid lost most of its structural strength in all but the sulfuric acid.

▶**Most Resistant**—The most corrosion resistant of the three plastics tested was bisphenol A, made from propylene oxide, bisphenol A and fumaric acid. This polyester survived all the test media for a year, and retained a large part of its original flexural strength in all the solutions except nitric and acetic acids.

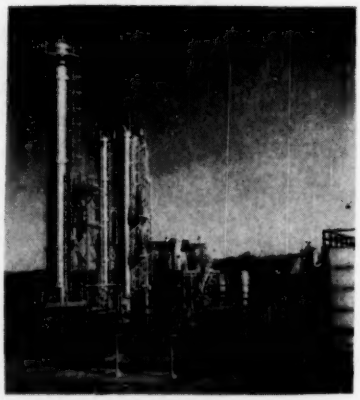


CPI NEWS BRIEFS . . .

(Continued from page 108)

the mixture rather than pure benzene is to avoid freezing in Buckeye's pipeline.)

Allied Chemical Corp.'s National Aniline Div. has doubled its production capacity for succinic anhydride by starting up an additional plant at Buffalo. The division states that it is the sole domestic producer of this material.



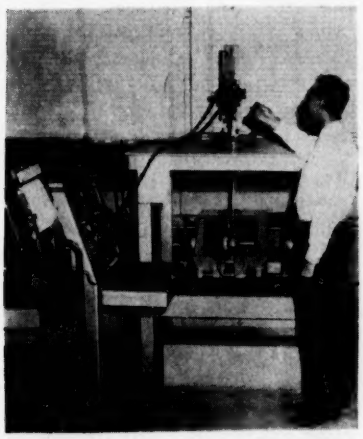
Hercules Powder Co.'s Explosives Dept. has begun operation at Hercules, Calif., following completion of a multimillion-dollar expansion program. Included in the program are an 8-million-gal./yr. methanol unit (pictured above), and facilities to make 50 million lb./yr. formaldehyde and 11,000 tons/yr. urea-formaldehyde compositions. The methanol plant is said to be the only one on the West Coast.

Celanese Corp. of America announces completion of a multimillion-dollar expansion of acrylate esters production capacity at the Pampa, Tex., plant of the firm's subsidiary, Celanese Chemical Co. Newly completed facilities are designed to produce 14 million lb./yr. of butyl acrylate, 2-ethylhexyl acrylate and glacial acrylic acid, and the Pampa plant's total acrylate capacity is now 30 million lb./yr.

B. F. Goodrich Chemical Co. plans to start commercial production of its new high-temperature vinyl resin, Geon, around May 1 at the firm's Louisville, Ky., plant.

American Potash & Chemical Corp., has a $5-million manganese plant under construction at Aberdeen, Miss. Facility, due on stream in November, represents company's first commercial venture in manganese. Site is adjacent to an existing AP&C sodium chlorate plant, and the contractor for the project is the Stearns-Roger Manufacturing Co., Denver.

Bestwall Gypsum Co., National Gypsum Co. and **John Deere Chemical Co.,** all of which have manufacturing operations in the Pryor, Okla., area, are jointly building a $500,000 industrial-waste disposal plant at that location to serve the three firms. In addition to the plant itself, the project will include a 4.5-mi. waste collection system and two accumulation basins having areas of 175 and 65 acres.



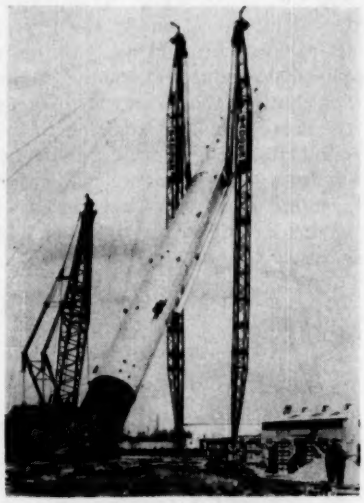
Schlumberger Corp.'s Ridgefield Instrument Group, Ridgefield, Conn., has opened an analytical service center at that city. It is equipped to use advanced methods of radio-frequency spectroscopy in supplying sample analyses and spectrum interpretations for customers. Shown above is equipment for study of free radicals, radiation damage sites, paramagnetic transition metals and other substances with unpaired electrons.

Pacific Laboratories, a new Hawaiian firm, has placed a $400,000 hydrolytic-enzymes plant on stream. Based on a new low-cost

CPI NEWS BRIEFS . . .

process developed by Japanese scientists, facility is designed to produce pure enzymes of high catalytic power coupled with low susceptibility to temperature and humidity changes. Product will be marketed through Western Biochemical Corp., San Francisco.

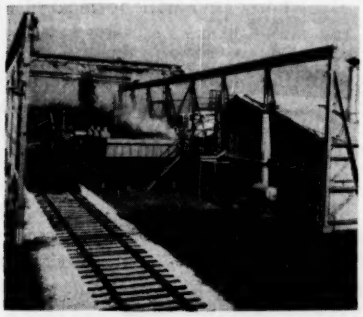
Shell Oil Co. is installing a 5,000-bbl./day lube oil hydrotreater at its refinery in Martinez, Calif. Completion is scheduled for this summer.



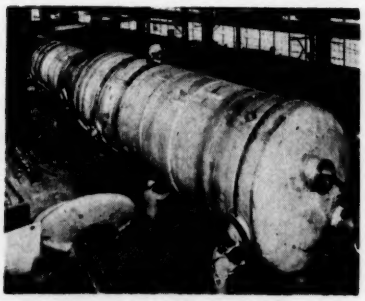
Sinclair-Koppers Chemical Co., Inc., will have what is described as the tallest one-piece process tower ever erected as part of its forthcoming 70-million-lb./yr. styrene plant at Houston. Shown being positioned above, the column is 227½-ft. tall and weighs over 600,000 lb. with insulation. It is the first of eight vessels that will make up the plant's main fractionation unit. Engineering and construction of the plant is by Badger Mfg. Co., Cambridge, Mass., and the tower was fabricated by Wyatt Industries, Inc., at that firm's shops in Houston.

Allegheny Ludlum Steel Corp. has placed on stream a vacuum-smelting furnace, described as the world's largest, at its Watervliet Works near Albany, N. Y. Furnace will turn out ingots of superalloys and other high-alloy steels weighing as much as about 30 tons and measuring up to 50 in. in diameter.

McDanel Refractory Porcelain Co. plans a 25% expansion of floor space at its Beaver Falls, Pa., industrial-ceramics plant. Scheduled for completion by mid-'61, expansion program will lead to increased kiln facilities, improved production techniques, more laboratory and inventory space.



Metal & Thermit Corp. has officially opened a new plant at Tampa, Fla., that will recover tin from tin plate scrap. Facility, shown above, cost a half million dollars, occupies an 11-acre site.



Colonial Iron Works Co. has recently expanded fabrication facilities at its Cleveland plant; new equipment includes a 10-ft. vertical boring mill, a gap lathe, 7- and 8-ft. radial drills, a 260,000-v. X-ray unit and other items. A recent product of the expanded works is the 50-ton distillation column shown above, described as the largest of its kind built in the U.S. (It is 80 ft. long, 12 ft. in dia., contains sieve trays and is valued at about $200,000.)

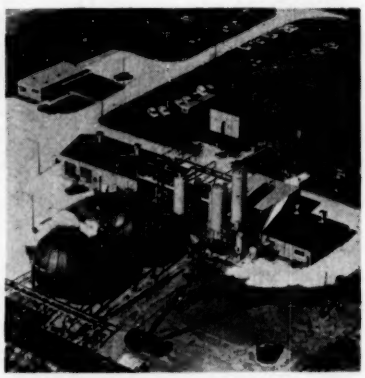
Colonial describes itself as one of only a few firms in the country that offer integrated services extending from process design of a unit to its fabrication.

CPI NEWS BRIEFS . . .

Mobil Chemical Co. will erect a research and development facility on a 14-acre site at Edison Township, N. J., adjoining a plant of Socony Paint Products Co. Approximately four fifths of the new building's floor space will be devoted to laboratory use, the remainder to office and service facilities. Eighty scientific and technical personnel will be located at the site.

Manning, Maxwell & Moore, Inc. is building a one-story, 125,000-sq. ft. plant on a 100-acre site at Alexandria, La., to manufacture safety and relief valves. Due on stream by September, the $2.2-million facility will absorb operations presently carried out in Tulsa, Okla., and Stratford, Conn.

Air Reduction Sales Co. has signed a contract with Bethlehem Steel Co., under which the former will construct and operate a tonnage oxygen plant for Bethlehem's blast furnaces at Johnstown, Pa. Now under construction, the $5-million, 675-ton/day plant is described as the steel industry's largest single-column air-separation facility. It is scheduled for completion in September.



Linde Co., Div. of Union Carbide Corp., is on stream with a new liquid oxygen-nitrogen plant at Neosho, Mo. Having a capacity of 140 tons/day, the unit supplies rocket engine development facilities at nearby Fort Crowder; part of its output will also go to industrial gas consumers throughout the Southwest. Included at the plant, shown above, are two stor-

age spheres that can each hold the liquid equivalent of 25 million cu. ft. of gas.

Molded Fiber Glass Cos. has doubled the capacity of its polyester resins plant at Ashtabula, Ohio. New figure is 10 million lb./yr., and the expansion is aimed specifically at efficient production of isophthalic-based resins. Total plant output goes to five affiliated MFG companies for fabrication.

Max Factor & Co. has a new cosmetics-manufacturing plant at Hawthorne, Calif. Described as the most modern unit of its kind, it consolidates operations formerly carried out in three Hollywood buildings and also represents a complete redesign of the firm's manufacturing processes. Engineering, design, purchasing and construction were by Jacobs Engineering Co., Pasadena, Calif.

Oak Ridge National Laboratory, operated by Union Carbide Corp. for the AEC, has completed a six-fold expansion of its facilities for separating stable isotopes. Program was accomplished by reactivating and modernizing 24 electromagnetic separators that were formerly used to extract U-235.

The Goodyear Tire & Rubber Co. is starting construction on a $1.5-million expansion of its research facilities at Akron, Ohio. Project consists of a three-story building wing, containing 25,500 sq. ft. floor space, that will enlarge the existing laboratory by 30%. The construction is due ready for occupancy by the end of this year.

Offices

Parke, Davis & Co. has begun operations in a new $500,000 distribution center at Memphis, Tenn.

Fisher Scientific has purchased a four-acre complex of land and buildings in Houston to house its recently established Southwestern Div. Main building on the site contains 3,000 sq. ft. for air-conditioned offices, 37,000 sq. ft. of warehouse space, and demonstra-

tion laboratories and instrument service-and-repair shops.

Petroleum Chemicals, Inc., will move its main offices from New Orleans to Lake Charles, La. The transfer will involve relocating 20 of the company's executives.

Chicago Bridge & Iron Co. has transferred the headquarters of its process division from New York to Chicago.

Beckman Instruments, Inc.'s Scientific & Process Instruments Div. has opened a sales office in St. Louis.

Companies

COMCO Corp., Philadelphia, is a new firm that manufactures and markets equipment for materials classification and conveying. Among its products are a system of vibratory screens and conveyors that transmit no vibration to their foundations, and a line of hydraulic classifiers and dewatering equipment. Manufacturing operations are carried out in the U. S. and the firm's marketing area is to include the whole Western Hemisphere.

Midland-Ross Corp. and **Industrial Rayon Corp.,** both of Cleveland, have approved in principle a merger proposal that would result in the latter firm operating as a division of the former. Shareholders of each company will act on the proposal at special meetings late in April. Midland-Ross designs and manufactures diversified products for the automotive, steel, appliance, food, paper and other industries and also for government aeronautics programs; Industrial Rayon produces rayon tire cord and textile rayon yarn.

The Borden Co., New York, has acquired Hawley-Monk Co. of Cincinnati, a manufacturer of inks, varnishes and related materials for the graphic arts industry. The newly acquired firm will

complement the facilities of Commercial Ink & Lacquer Co., a division of Borden's subsidiary, Borden Chemical Co.

The Dow Chemical Co. has formed a new Metals Dept., which will consolidate various Dow activities in magnesium and other primary metals. The new department is separate and distinct from The Dow Metal Products Co. Div., which processes and fabricates aluminum, magnesium and other mill products.

International

Indonesia's government has awarded a contract for a $38-million urea plant to be built at Palembang, Sumatra. It will process natural gas feedstock, will have capacity of 100,000 metric tons/yr. Morrison-Knudsen International Contractors, Inc., is handling the project in association with H. K. Ferguson Co. (an M-K subsidiary) and Girdler Construction Co. Construction is due to be completed by the end of 1963.

Japan: A new, joint-venture aluminum company is slated to build a $44-million refinery and rolling plant in central or western Japan. Japanese participants in the venture are Yawata Iron & Steel Co., Ltd., Nisso Steel Mfg. Co., Ltd., and Kinoshita Sansho Co.; a possible fourth entrant is Kaiser Aluminum & Chemical Corp., which may put up about 30% of initial $5.6-million capital required and supply technical know-how. Initial capacity of the refinery is to be 25,000 tons/yr.; it is scheduled to be completed early in 1963.

Saudi Arabia: Arabian American Oil Co. has begun construction of a $7.5-million LPG injection plant at Abqaiq, which will collect and compress 55 million cu. ft./day of low-pressure gas for injection in the 'Ain Dar oil reservoir. Project is part of Aramco's program to conserve gas and increase recoverable oil reserves.

Convention Calendar

April

9-13. American Society of Mechanical Engineers, Oil & Gas Power Conference and Exhibit, Jung Hotel, New York, N. Y.

10-11. American Institute of Electrical Engineers, Rubber and Plastics Industries Conference, Sheraton Hotel, Akron, Ohio.

10-11. American Society of Mechanical Engineers, Maintenance & Plant Engineering Conference, Bancroft Hotel, Worcester, Mass.

10-11. The Combustion Institute, Western States Section, 1961 Spring Meeting, Aeronutronic, Newport Beach, Calif.

10-12. The Metallurgical Society of American Institute of Metallurgical Engineers, 44th Annual Conference, Sheraton Hotel, Philadelphia, Pa.

10-12. Western Petroleum Refiners Assn., 49th Annual Meeting, Grenada Hotel, San Antonio, Tex.

10-13. American Management Assn., National Packaging Exposition, McCormack Place, Chicago, Ill.

11-12. American Institute of Electrical Engineers, Materials Handling Conference, Pick-Congress Hotel, Chicago, Ill.

11-12. Instrument Society of America and the Society For Applied Spectroscopy, 1961 Ohio Valley Instrument-Automation-Electronic Exhibition and Symposium, Cincinnati Gardens, Cincinnati, Ohio

11-13. American Society of Lubrication Engineers, Annual Meeting & Exhibit, Bellevue-Stratford Hotel, Philadelphia, Pa.

13-14. Oklahoma State Univ., Heat Transfer Conference, Stillwater, Okla.

13-15. The Metallurgical Society of American Institute of Metallurgical Engineers, Pacific Northwest Metals and Minerals Conference, Davenport Hotel, Spokane, Wash.

17-19. Instrument Society of America, 7th National Symposium on Instrumental Methods of Analysis, Shamrock-Hilton Hotel, Houston, Tex.

17-19. Purdue University, Conference on Manufacturing Automation, Lafayette, Ind.

18-20. National Institute for Disaster Mobilization, Industrial Mutual Aid & Disaster Control Seminar, Shamrock-Hilton Hotel, Houston, Tex.

18-20. American Welding Society, An-

nual Welding Exposition, Coliseum, New York, N. Y.

19-22. Instrument Society of America, 7th Southeastern Regional Conference and Instrument Exhibit, Park Center, Charlotte, N. C.

20-21. The Society of the Plastics Industry, Inc., 18th Annual Western Section Conference, Hotel del Coronado, Coronado, Calif.

20-21. American Institute of Mining, Metallurgical and Petroleum Engineers, Gas Technology Symposium, Tyler, Tex.

23-26. American Society of Mechanical Engineers, Metals Engineering Conference, Penn Sheraton Hotel, Pittsburgh, Pa.

26-27. American Institute of Mining, Metallurgical and Petroleum Engineers, High Temperature Materials Conference, Pick-Carter Hotel, Cleveland, Ohio.

26-28. American Rocket Society, Propellants, Combustion and Liquid Rockets Meeting, Palm Beach Biltmore Hotel, Palm Beach, Fla.

May

2-4. Purdue University, 16th Purdue Industrial Waste Conference, Purdue Memorial Center, LaFayette, Ind.

3-13. 5th Annual United States World Trade Fair, New York Coliseum, New York, N. Y.

4-5. American Institute of Mining, Metallurgical and Petroleum Engineers, Oil Recovery Conference, Midland, Tex.

7-10. American Institute of Chemical Engineers and the Chemical Engineering Div., Chemical Institute of Canada, Joint Meeting, Sheraton-Cleveland Hotel, Cleveland, Ohio.

8-10. Instrument Society of America, National Power Instrumentation Symposium, LaSalle Hotel, Chicago, Ill.

8-10. Technical Assn. of the Pulp and Paper Industry, 12th Annual Coating Conference, Statler Hotel, Buffalo, N. Y.

Later

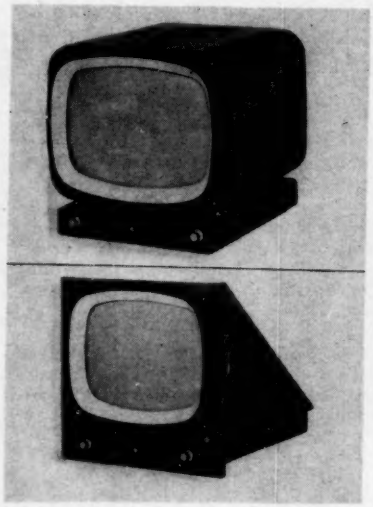
June 21-23. American Assn. of Cost Engineers, Annual Meeting, Somerset Hotel, Boston, Mass.

November 27-December 1. 28th Exposition of the Chemical Industries, New York Coliseum, New York, N. Y.

NEW EQUIPMENT . . .

(Continued from page 118)

clude: easy repair in case of wreck, no corrosion problem, reduced paint and other maintenance costs.—**National Aniline Div., Allied Chemical Corp., New York.** **118E**

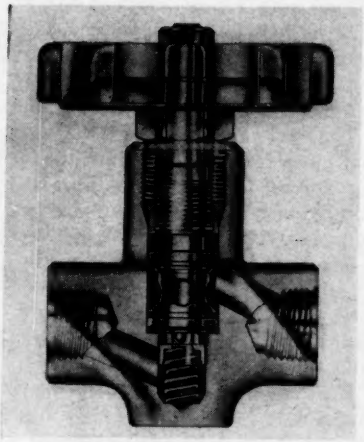


TV monitor

Closed-circuit industrial unit boasts expanded brightness range.

In areas of high ambient light, polarized faceplate on this portable television monitor minimizes reflection and maximizes contrast ratio. Unit is simpler to maintain and adjust than home sets, and is ballyhooed to have "three times the picture quality." Standard monochrome camera feeds it operating signal.

Horizontal resolution is 800 lines minimum, degradation negligible after continuous operation for 24 hr. Brightness, stability and detail are promised over total viewing area—which, depending on the model, would be 14, 17 or 21 in. of screen. Size, focus and linearity controls are separate. Cabinet's sides are removable for easy repair, as is the panel covering aluminum chassis' bottom. Handle on top of the monitor makes for convenient carrying.—**General Electric Co., Lynchburg, Va.** **194A**

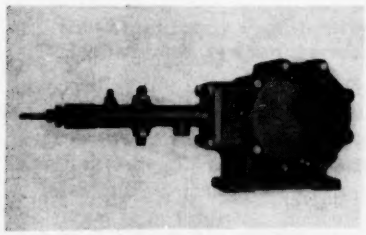


High-pressure valve

Stainless steel unit serves under exceptionally corrosive conditions.

Rated to 6,000 psi. in liquid or gaseous service, a new high-pressure shutoff valve is made of stainless steel and Teflon for use in corrosive applications. Called 920-T, it features V packers instead of O-rings for a tight seal.

The Teflon seals can be replaced in the valve without removing it from the line. Stem threads are completely removed from the flow path to permit permanent lubrication and prevent product from being contaminated with lubricant. A floating sleeve rises to protect the packers from fluid flow when the valve is open.—**Circle Seal Products Co., Inc., Pasadena, Calif.** **195A**



Cryogenic pump

Single-cylinder, high-pressure unit is designed for low, medium flows.

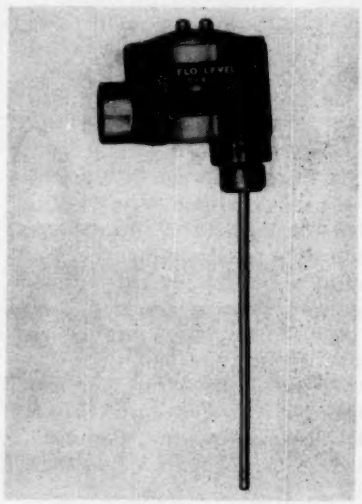
Designed for ultralow temperatures, a new positive-displacement pump delivers up to 4.65 gpm.

NEW EQUIPMENT . . .

(26,000 scfh. N_2) of liquefied gases such as oxygen, nitrogen and hydrogen. An intermediate section separates the cryogenic pumping end from the ambient drive end.

The cold end, having a low thermal mass for rapid cooldown during startup, requires no lubrication except for the fluid being pumped. Net positive suction heads as low as 10 psi. are made possible by special design of the inlet port and a vent port that removes entrained gas from the inlet liquid, preventing cavitation.

Heat transfer from the drive end to the cold end is reduced by the dead-gas space of the interbody. —**The Cosmodyne Corp., Hawthorne, Calif.** **195B**



Level controller

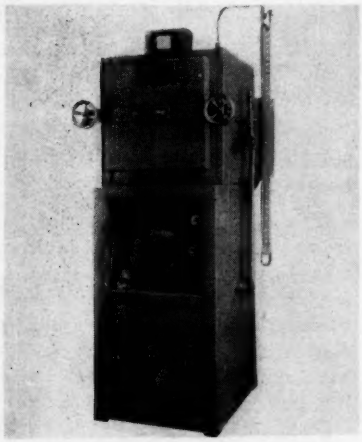
Self-contained capacitance-type probe senses wet, dry levels.

Explosionproof and fully contained, this level controller is best suited for lightweight, low-capacitance powders and pellets. However, it also controls liquids.

Presence or absence of material at specified level is detected by probe through changes occurring in an electrostatic field. Signal is pulsed to control circuit, which activates two-way snap-action relay. Relay, in turn, operates filling or shutoff switch.

Threaded hub permits quick

mounting on container wall. Standard probe length is 6 in., but longer lengths are available on request. Circuitry is for either 110- or 220-v. power supply.—**Flo-tronics, Inc., Minneapolis.** 196A



High-vacuum oven

Complete bakeout system works at 10^{-5} mm. Hg vacuum.

For research or production, this high-vacuum oven comes as a console-cabinet unit, enclosing oven, pump and vacuum gaging.

Two models (in three sizes) are available: front or pit loading, with pumping systems for either 10 microns or 10^{-5} mm. of mercury. Oven temperature is controlled to 500 F. by an indicating thermostat. Backfill gage and valve are included.—**Gruenberg Electric Co., Garden City, N. Y.** 197A

Hand pump

Double-acting, corrosion-resistant unit takes liquids "indefinitely."

In this design, double diaphragms keep the liquid sandwiched between them instead of allowing contact with the pump body. Diaphragms themselves are fabricated of a "deterioration-resistant" synthetic rubber, contain integral O-ring seals for anti-leak protection.

Pumping is accomplished on

both push and pull strokes; about 100 push-pulls are needed to move 78 gal. Need for a packing or stuffing box is eliminated—in fact, nylon shaft bearing is the only friction point in the unit.

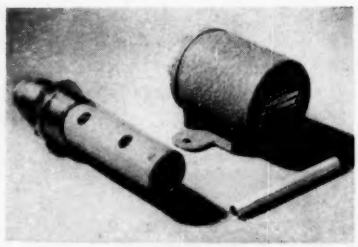
Four models are available, plus an assortment of accessories.—**The Wayne Pump Co., Fort Wayne, Ind.** **197B**

Heater

Sudden-expansion type burner heats to 5,600 F. at 1,000 psi.

Based on designs simulating extreme ramjet and rocket environments, new-type superheater is applicable to a number of processes and industrial systems, including partial-oxidation reactors, high-temperature materials testing, intermittent steam generation.

Compact, all-metal unit can be air- or water-cooled depending on individual requirements. Heater utilizes high-velocity combustion technique to obtain superhigh thermal capacity. Broad temperature modulation capabilities permit stable, continuous operation from 150-5,600 F.—**The Marquardt Corp., Van Nuys, Calif.** **198A**



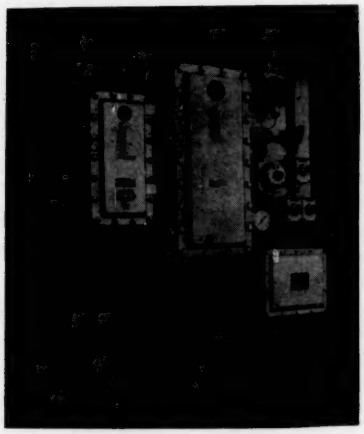
Level controller

Switch can't be made to err by drop of liquid clinging to it.

Dual-crystal design makes it impossible for a drop of liquid stuck on the sensor of this device to influence its control—only a complete liquid path between sensing elements will cause it to respond.

Ultrasonic switch is a small,

light, rugged unit with low power requirements and an accuracy within ±1-in. It serves such purposes as high- or low-level warning and control, flow monitoring, leak detection. Probe has temperature range of 250 C. down to −95 C.; control unit has a range of 100 to −65 C. It has no moving parts.—**The Liquidometer Corp., Long Island City, N. Y.** 198B



Heat transferer

Electrical, explosion-resistant unit is self-contained, portable.

Ready for hookup to any adaptable fluid process needing constant heat, such as those using jacketed vessels and pipelines, this heat-transfer unit will hold a steady temperature at any value up to 600 F.

Constructed on a heavy-duty steel framework, system is equipped with electric immersion heaters, high-temperature pumps, bypass relief valve, expansion tank, temperature controls, contactors and safety devices. — **Radcor, Inc., Bradner, Ohio.** 199A

Briefs

Polyvinylchloride needle valve, available in four sizes, is machined instead of molded, yielding precision tolerances. Rated for 100 psi. at 73.4 F, airtight valve

handles liquids and gases up to 150 F. and down to "sub-zero" temperatures. — **Oscar Davis Co., Inc., Paterson, N. J.** **199B**

Liquid leak detector, sprayed in thin, solid stream on pressurized air- or gas-line connections, forms bubbles if vapor is leaking. Application spout extends from ½-12 in. for directing flow to hard-to-reach locations.—**Nuclear Products Co., Cleveland.** **200A**

Gasket compound leakproofs gasketed assemblies from −65 to +400 F. at up to 5,000 psi. Soft-set type remains plastic for joints that periodically are disassembled. Hard-set type dries quickly, sets hard, withstands vibration and heat expansion.—**Crane Packing Co., Morton Grove, Ill.** **200B**

Steel strainer will take 2,000 psi. at 1,050 F.; 6,000 psi. at 100 F. Forged from chrome-moly steel, it fits ¾ to 1½-in. pipes, has socket weld connections. Screen is Monel sheet with 0.045-in. holes.—**Armstrong Machine Works, Three Rivers, Mich.** **200C**

Equipment Cost Indexes . . .

	Sept. 1960	Dec. 1960
Industry		
Avg. of all	237.4	237.3
Process Industries		
Cement mfg.	231.7	231.6
Chemical	238.6	238.1
Clay products	225.6	225.1
Glass mfg.	225.3	224.8
Paint mfg.	229.1	229.4
Paper mfg.	229.9	229.4
Petroleum ind.	234.0	234.3
Rubber ind.	237.9	237.1
Process ind. avg.	236.2	236.1
Related Industries		
Elec. Power equip.	240.2	238.3
Mining, milling	240.0	239.5
Refrigerating	267.7	268.0
Steam power	224.3	224.5

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124-6 for method of obtaining index numbers; Mar. 6, 1961, pp. 115-116 for annual averages since 1913.

Technical Bookshelf

POLLUTION PARLEY

PROCEEDINGS OF THE INTERNATIONAL CLEAN AIR CONFERENCE. NATIONAL SOCIETY FOR CLEAN AIR, LONDON, 1960. 290 pages. 30s net (plus 2s. 6d. for postage).

Reviewed by W. L. Faith, Air Pollution Foundation, San Marino, Calif.

"An industrial society has many advantages but one of the disadvantages is dirt. The water and the air is full of it and this pollution kills fish and vegetation, covers the countryside with grime, turns buildings black and starts them crumbling, and attacks our lungs sometimes with fatal results."

Thus H. R. H. Philip, the Duke of Edinburgh and Patron of the Conference, opened his message to the meeting in London in October 1959. The conference was largely British in tone and dealt primarily with smoke, dust, grit, and sulfur dioxide from the burning of solid fuels.

The proceedings contains the 78 papers that were presented from 17 countries. Papers were generally quite abbreviated, sometimes being mere outlines of the subject matter.

National air pollution problems in 14 countries were reviewed in 20 brief accounts.

Nineteen papers in a "technical" session dealt with control methods for combustion effluents, but contained little information not published elsewhere. Those who have access to the proceedings might be interested in Kay's article on arsenic contamination and control in smelting operations, and in an Italian article on the effect of organic nitrate base additives on the NO_x and CO content of diesel exhaust.

The session on observations and measurement of air pollution (19 papers) is a good source of data on dustfall and atmospheric SO_2, chiefly in European cities. Fairly complete resumes were presented for Paris and Padua, Italy. The session on research (20 papers) contained little not available elsewhere. As in most proceedings of British meetings, reporters' reviews and some discussion are given as an addendum.

Over-all, the volume is recommended to those collecting air pollution memorabilia.

FERTILIZER FAMILIARIZER

THE CHEMISTRY AND TECHNOLOGY OF FERTILIZERS. ED. BY VINCENT SAUCHELLI. REINHOLD PUBLISHING CORP., NEW YORK. 692 pages. $18.

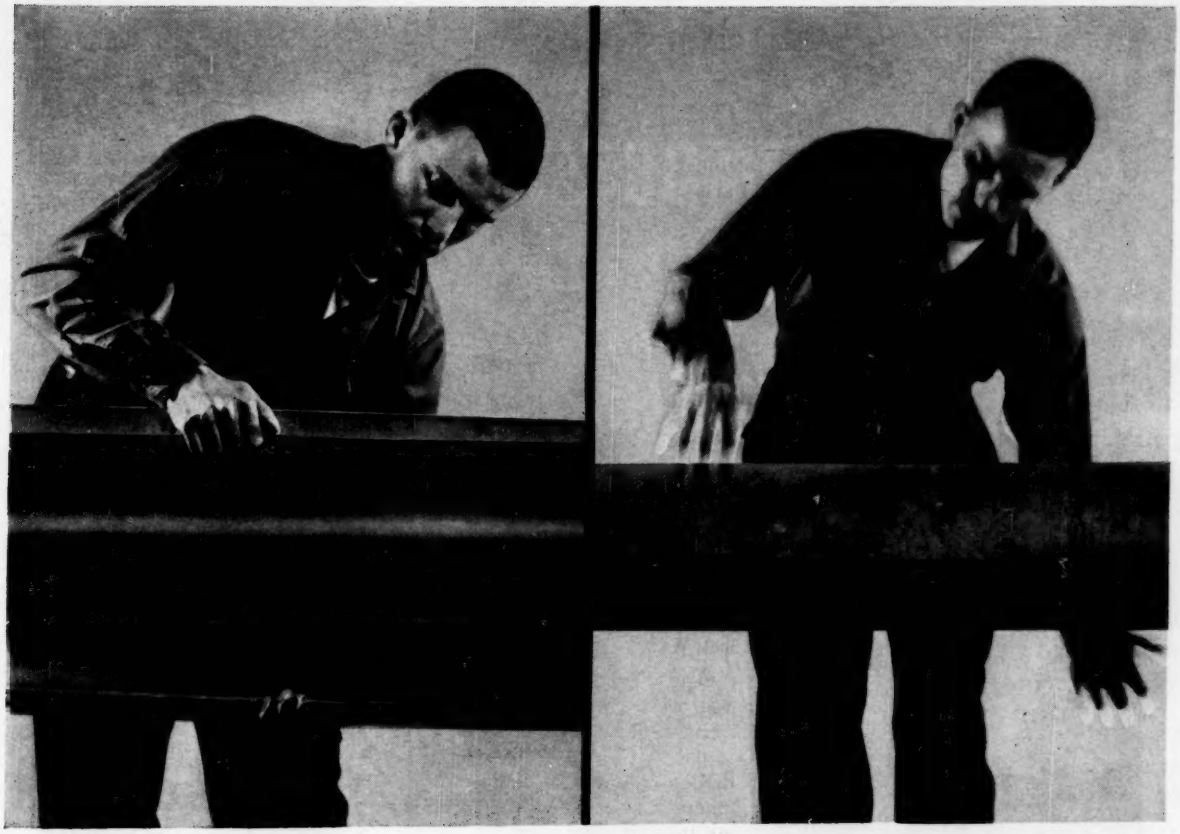
Reviewed by Richard J. Callahan, Chemical Week, *New York City.*

As is so often the case in multi-authored works, this ACS monograph has the defect of being uneven in pace and level of its attack, the virtue of viewing its subject from more than one angle. Considering its stated objective, i.e., to be a complete, authoritative survey of the entire chemical fertilizer industry, the virtues outweigh the defects.

Particularly good is treatment of the broad aspects of the industry; somewhat less rewarding—the absence of hard information on equipment (surely this falls under any purview of the "entire chemical fertilizer industry") as well as the too-small insight we are given into nonfarm fertilizer usage.

Among the topics covered: manufacture of each of the principal types of bulk fertilizers, background material on the evolution of these products, handling problems encountered in such manufacture. Accompanying flowsheets are as a rule well done, and photographic material is better than average for a book on this subject.

For a broad introduction to the fertilizer industry, especially at the production level, this book should prove of good value to chemical engineers and plant superintendents. For those interested in the economics and marketing of fertilizers, it may be too general to warrant its price.



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In Rapid Review

Introduction to Nuclear Science. By Alvin Glassner. D. Van Nostrand Co., Princeton, N. J. 213 pages. $3.75. This elementary, but very sound text was written for high school science teachers attending a summer nuclear science course at the Argonne Nat'l. Laboratory. In addition to chapters on the nuclear atom and its physics, the book covers high-energy accelerators, reactors, uranium metallurgy and reactor fuel processing, and the effects of radiation on both materials and organisms.

The Matheson Gas Data Book. This third edition of an old standby lists 81 compressed gases. For each one, there is a table of physical constants, frequently supplemented by charts and graphs of thermodynamic properties. This is followed by data on toxicity, uses, and safety precautions. Shipping regulations and recommended controls are covered and preparation and chemical reactions are briefly noted. Write: The Matheson Co., Inc., P. O. Box 85, East Rutherford, N. J. $8.

More New Books

Viscoelastic Properties of Polymers. By J. D. Ferry. Wiley. 482 pages. $15.

The Story of Alchemy and Early Chemistry. By J. M. Stillman. Dover. 566 pages. $2.45 (paperback, reprint).

Ternary Systems. By G. Masing. Dover. 165 pages. $1.45 (paperback, reprint).

Dictionary of Mechanical Engineering. By A. Del Vecchio. Philosophical Library. 346 pages. $6.

Waste Disposal in the Marine Environment (Proceedings of 1st International Conference). Ed. by E. A. Pearson. Pergamon. 569 pages. $12.50.

Thermodynamics. 2nd ed. By G. N. Lewis and M. Randall. Revised by K. S. Pitzer and L. Brewer. McGraw-Hill. 723 pages. $12.50.

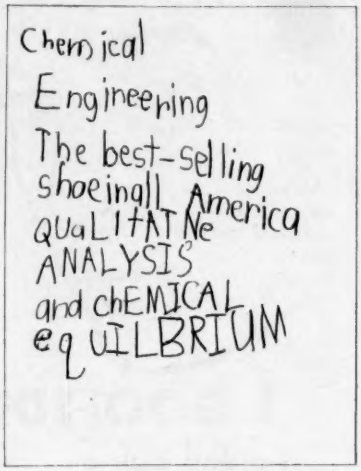
The Chemical Warfare Service. By L. P. Brophy, W. D. Miles and R. C. Cochrane. Dept. of the Army. Write: Supt. of Documents, U. S. Govt. Printing Office, Wash. 25, D. C. 498 pages. $3.50.

Pyridine and Its Derivatives. Part 2. Ed. by E. A. Klingsberg. Interscience. 576 pages. $37.50 ($32.50 by subscription).

The Chemistry of the Terpenes. By A. R. Pinder. Wiley. 223 pages. $8.25.

Heterocyclic Systems with Bridgehead Nitrogen Atoms. Part 1. By W. L. Mosby. Interscience. 747 pages. $48 ($43 by subscription).

Letters: Pro & Con



Pro: CE as a Copybook

Sir:

Our six-year-old future engineer is learning to print. He goes off by himself and copies words out of magazines.

The enclosed was taken from your publication, mixed with something obviously from another source. It gave us such a laugh we thought you would enjoy it also.

PAT COSTELLO

Albany, Ga.

Another CEQ Test

Sir:

Mr. T. G. Borras's problem about the tank with double feed and drain pipes (Feb. 6, p. 162) reminds me of one that Mr. S. F. White of our personnel staff often used:

If a tinker and his helper can refabulate a widget in 2 hr., the tinker and his apprentice can refabulate the same widget in 3 hr., and the helper and the apprentice can do the job in 6 hr., then how long would each of them take, working alone, to refabulate the widget?

C. H. WHICHER

Aluminum Co. of Canada

Arvida, Que.

▶ *We think it would be more fun to figure out how long it would take a chemical engineer to refabulate a widget.*—ED.

Filing Problems

Sir:

I wonder if by any chance you have some sort of system available by which technical information may be arranged? The articles and other information in my personal library are always getting into a heck of a mess, and I can never find something when I want it.

Maybe some sort of coding setup for these items? Just some way to keep things well arranged and findable when some piece of information is needed?

For the life of me, I can't come up with a decent cataloging system.

JERRY HECKMAN
University of Colorado
Boulder, Colo.

▶ *We, too, would be happy to hear from any of our readers who have developed workable systems for filing technical information.*—ED.

Job-Hunting Experience

Sir:

Peter Brennan's "What It Takes to Get That New Job" (Feb. 20, pp. 158-62) should prove an invaluable aid to engineers seeking employment. I regret that this article was published *after* I had engaged in a very disheartening job hunt.

However, this article covered only one aspect of employment seeking. An employed engineer seeking a new position must use a somewhat different approach from that used by an unemployed

PRO & CON . . .

engineer. Also, the picture from the employers' side is obscure, especially regarding their desires and policies.

I hope that future issues of *CE* will carry articles on different phases of job-hunting. Certainly this important aspect of an engineering career should be covered from all angles.

MARVIN FLEISCHMAN
U. S. Public Health Service
Rockville, Md.

World-Wide Refresher Course

Sir:

I was interested to note your news item regarding the new Engineering Fundamentals course (Jan. 23, p. 156).

Unfortunately, you omitted what was probably the most important part of this announcement. This is that the course is offered by correspondence and is readily available to engineers all over the nation (the world, too—one student is located in Saudi Arabia).

I am sure many of your readers would be interested in knowing that such a course is as close as the nearest mailbox, rather than in Berkeley, Calif., as many would infer from the item as it was published.

LLOYD M. POLENTZ
Professional Engineering Consultant
Whittier, Calif.

▶ *We're happy to clarify this point at the suggestion of Consultant Polentz, who developed this engineering refresher course.*—ED.

Nomenclature Error

Sir:

There is an inconsistency in Figs. 1, 2 and 3 of the article, "Estimating Air-Cooled Exchangers Made Easy," appearing in your Feb. 6 issue (pp. 99-100). The abscissas of these figures are shown incorrectly as h_i. They should read h_{io}.

JOSEPH W. MURTHA
Bechtel Associates
New York, N. Y.

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212A Technicon Controls, Inc.

* From advertisement, this issue

Benzoic Acid.....2-page data sheet presents a proposed methodology for continuous automatic determination of benzoic acid content of fluids. Flow diagram is included.
213A Technicon Controls, Inc.

Catalysts.....Bulletin describes use of all-metal gas purification catalysts to produce industrially pure gases, that can operate at high or low pressures and temperatures to 1500°F.
213B Catalytic Combustion Corp.

Drying Agent.....Driocel-S is a special activated bauxite drying agent for overcoming souring of hydrocarbon liquids. Samples & complete technical data available.
18-19b *Minerals & Chemicals Philipp

Fluorides.....Company offers a copy of M. C. A. Chemical Safety Data Sheet SD-25 on properties & essential information about hydrofluoric acid, anhydrous & aqueous.
68 *The Harshaw Chemical Co.

Fungicide, Bactericide.....Brochure describes characteristics of "Preventol GD and Preventol GDC", two non-volatile, chemically stable and non-irritating agents.
213C Antara Chemicals

Granular Carriers.....Granular Attaclay is available in a variety of mesh sizes. They are the most widely used carrier material for herbicides. TI-153 offered.
18-19b *Minerals & Chemicals Philipp

Helium.....Information circular 8018 "Helium Production at the Bureau of Mines Keyes Helium Plant" gives detailed information on the operation of the government's new plant.
213D Bureau of Mines

Hydrofluoric Acid.....The convenience and flexibility of tank-transport delivery is now being provided. Aqueous Hydrofluoric Acid for immediate delivery.
85 *Allied Chemical

Lubricant.....4-page brochure details results in the use of "Hi-T-Lube", a new high temperature dry lubricant that has performed effectively for three hours at over 1,000°F.
213E General Magnaplate Corp.

Want to build up your files and keep them up-to-date? You can get any publication in this comprehensive guide — free — just for the asking.

It's easy — simply circle item's number on the Reader Service Postcard and mail. Replies will come directly from companies offering the liaterature.

LITERATURE . . .

Lubricants.....26 different types of cutting fluids and lubricants are covered in a 52-page catalog. Physical and chemical properties, uses and descriptions are tabulated.
214A Shear-Speed Chemical Products

Nitromethane.....10-page technical data sheet contains information on the storage and handling of compound and includes chart on mutual effect of nitromethane.
214B Commercial Solvents Corp.

Organics.....can be manufactured to your specifications, in quantities from a few gallons to tank car lots. A more detailed outline in Bulletin K-6.
R201 *Nalco Chemical Co.

Oxo Alcohol.....performs as an efficient non-volatile plasticizer for 90 deg. C. wire yet reduces plasticizer cost. Technical Bulletin 20 is available on request.
95 *Enjay Chemical Co.

Oxygen.....Tonnage oxygen plants built and operated for your oxygen-nitrogen processes. No capital investment; you pay only for oxygen. Details available.
6-7 *Air Reduction Co.

Paint Extenders.....contribute highest hiding power. Data has been graphed so the formulator may select a pigmentation best suited to his performance requirements.
18-19a *Minerals & Chemical Philipp

Plastic Flow.....Pamphlet "The Real Flow-Behavior of Plastic Substances" by Dr. A. G. Epprecht is a technical discussion of viscous deformation of plastic substances.
214C Drage Products Inc.

Silicones.....New descriptive brochure, "Why Silicone-Based Paints Mean Less Maintenance" is available. Covers the new paints based on silicone resins.
49 *Dow Corning Corp.

Silicones.....Heat protection, low temperature flexibility, good electrical properties, resistance to weathering, etc. are properties of silicones discussed in brochure.
214D General Electric Co.

Silicones.....Illustrated with photographs, charts and graphs, booklet details what silicones are, describes their uses and suggests ways of adapting to new applications.
214E Union Carbide Corp.

Solvent.....Samples and information on Pent-Oxone solvent including complete graphs on viscosity and evaporation and its keto-ether action are available on request.
80 *Shell Chemical Co.

Thermoplastics.....Table shows significant physical, electrical, chemical and optical properties of nine thermoplastic materials. Data compiled from test reports.
214F Cadillac Plastic & Chemical Co.

Construction Materials

Adhesives, Coatings, Sealers.....54-page catalog lists military specifications, specification definitions and applications for a wide variety of adhesives, coatings and sealers.
214G Minnesota Mining Manufacturing Co.

*From advertisement, this issue

Aluminum.....The light weight of aluminum lowers fabrication and erection costs. It is easy to weld and highly reflective. Complete literature file is available.
67 *Reynodls Metals Company

Brazing Alloy.....Material is described and engineering and brazing properties listed in data sheet that includes recommended uses and a case history application example.
215A Stainless Processing Div.

Castings.....Highalloy castings for processing are alloyed to meet high temperature & corrosive conditions. Further information in Bulletin G-159.
207 *Duraloy Company

Coating.....The Kanigen process for chemical nickel alloy plating produces a uniform thickness of coating, regardless of the contours of a part. Bul. 258.
175 *General American Trans Corp.

Coatings.....Nokorode coatings and their applications, uses and specifications are described in a technical booklet which is available on request.
56 *Lion Oil Co., Div. of Monsanto

Coatings & Enamels.....Imlar vinyl-mastic coatings & vinyl enamels have been developed for use where metal protective finishes are not recommnded. Bulletin.
46c *E. I. Du Pont de Nemours

Diatomite.....Celite assures consistent results and less down-time in every grade. Each grade has its own distinctive particle size distribution.
71 *Johns-Manville

Epoxy Enamels...Corlar epoxy chemical-resistant enamels have been developed for surfaces subject to severe corrosive conditions. Technical bulletin is offered.
46b *E. I. Du Pont de Nemours

Gaskets.....Spiral-Wound Gaskets for critical sealing applications using the proper metal, the proper filler and the proper yield characteristics for the specific job.
61 *Flexitallic Gasket Company

Gaskets.....Spirotallic gaskets give you a leakproof seal. Produced in a wide variety of sizes and shapes for standard & special flanges. Catalog PK-35A.
121 *Johns-Manville

Insulation.....The new Industrial Insulation Catalog is offered. Also Data Sheets on the complete line of accessories for use with Foamglas insulation.
75 *Pittsburgh Corning Corp.

Insulation, Pipe.....is available in full range of standard pipe sizes & in block form. Single thickness to five inches. Specials to 44" O.D. Bul. No. 65610.
39 *Union Asbestos & Rubber Co.

Material of Construction.....Booklet B-111B "Properties of Kennametal" and the new booklet B-666, "Proven Uses of Kennametal and Kentanium" are available on request.
216 *Kennametal Inc.

Metal Protective Finishes.....Dulux metal protective finishes can take care of 85% of your maintenance painting requirements. Details in technical bulletin.
46a *E. I. Du Pont de Nemours

* From advertisement, this issue

LITERATURE . . .

Mortars.....Polysulfide-base mortars provide a smooth or skidproof surface, as desired and are ready for traffic in less than one day. Brochure FC-100 is available.
91 *Thiokol Chemical Corp.

Packing.....Enjoy premium benefits without premium price with Garlock 5875 Teflon packing. Complete information on this useful packing is available in Catalog AD-185.
105 *Garlock, Inc.

Packings.....Chempro Teflon suspensoid impregnated asbestos packings have the chemical resistance of Teflon plus the strength of high grade asbestos. Bulletin CP552.
214 *Chemical & Power Products

Pipe Insulation.....Booklet contains specifications and data on Zebra pipe insulation. For low, medium & high temperatures. Made in large half-sections to speed application.
216A Keasbey & Mattison

Protective Coatings.....for steel tank linings, concrete floors, tank cars, etc. Selection of coatings & other Plasite products covered in booklet.
L237 *Wisconsin Protective Coating Co.

Synthetic Rubber.....Reference booklet "Industrial Report on Viton Synthetic Rubber" contains heat and fluid resistance data and also physical and resistance properties.
113 *E. I. Du Pont de Nemours & Co.

Thermal Insulation.....Thermal insulations for all types of commercial and industrial requirements, in applications ranging from —400 F to 3000 F are described in catalog.
216B Johns-Manville Corp.

Thermoplastic Sheetings.....A wide range of materials are used in these thermoplastic sheetings. Complete information on specific types of Seilon is available.
213 *Seiberling Rubber Co.

Electrical & Mechanical

Couplings.....are available in Brass, Malleable, Stainless, Aluminum, Monel, or other materials for corrosion resistance under any conditions. Illustrated Cat. C-11.
103 *Ever-tite Coupling Co., Inc.

Drive, Tube Expander.....Air-Magnetic drive is setting new records for speed and accuracy. Standard model handles most jobs—heavy duty for higher torque. Bul. Y-53.
200 *Elliott Company

Drive System.....Varidyne system features coordinated start and stop control and explosion-proof A.C. motors. Further details are contained in Brochure F-1963.
239 *U. S. Electrical Motors, Inc.

Drives.....Bulletin outlines extensive line of adjustable speed drives for application in the ¾ to 2500 hp drive range and describes four types of complete packaged drives.
216C The Louis Allis Co.

Encapsulated Motors....Bulletin #3750 describes introduction of "Capsular" insulation system for encapsulated random wound AC induction motors that offers added protection.
216D The Louis Allis Co.

* From advertisement, this issue

Motor.....TEIGF motor provides protection against expensive operation. Gas loss is lower than commercial standards. Further information is contained in Bul. 226.
58 *Electric Machinery Mfg. Co.

Motor Starters.....A new line of Bulletin 709 motor starters are the greatest advance in motor control in thirty years. More information is available.
69-70 *Allen-Bradley

Power Control Panels.....16-page bulletin gives detailed application data of grouped power control panels which utilize standard components arranged to customers requirements.
217A General Electric Co.

Pump Motors.....Bulletin covers close coupled pump motors, both polyphase and single phase and discusses mechanical variations that make close coupled pump motors.
217B Century Electric Co.

Safety Heads.....featuring quick change disks, accuracy and dependability. Offered in a wide variety of installation connections. Information in Bulletin SH-1160.
T219 *Instruments, Inc.

Starting Motors.....2-page pamphlet describes companies part-winding starting motors. Speed-torque characteristics are plotted as well as connections for part-winding starting.
217C Century Electric Co.

Thermocouple Cable & Wires.....in the widest variety of size, insulation, type and calibration, for your application. Information is contained in Bulletin 32-W5-4.
R205 *Thermo Electric Co., Inc.

Turbines..... built to customers' specifications, including API and NEMA standards. A complete range from 1 HP to 250 HP. Further facts in Catalog 200.
45 *Coppus Engineering Corp.

Turbines, Solid-Wheel.....seldom see down time because of bonus reliability built into each turbine. Further details are contained in Bulletin S-116.
57. *Terry Steam Turbine Co.

Handling & Packaging

Bulk Handling System.....with the efficiency and economy of automation and the flexibility and versatility of unit containers. New booklet gives details.
115 *Tote System, Inc.

Gas Transports.....Extreme mobility & economical storage make Taylor-Wharton gas transports ideal for bulk transportation of compressed gases. Information.
54 *Harrisburg Steel Co.

Industrial Scales.....feature "all steel" construction built to last a lifetime. Every type of scale to meet every possible use in the chemical industry. Information.
R222 *Cardinal Scale Mfg. Co.

Lift Truck.....A gas lift truck saves on initial price, save on maintenance and saves on operating costs. With cushion rubber tires or pneumatic tires. Details.
107 *Automatic Transp. Co.

* From advertisement, this issue

LITERATURE . . .

Loading Arms.....Bulletin 1-61 is available on request for complete information on a series of loading arms that measure up on every count.
24-25 *Chiksan Company

Magnetic Pulley.....In addition to preventing machinery damage, permanent magnetic pulleys prevent fires and explosions; assure product quality. Descriptive bulletin.
218A *Eriez Mfg. Co.

Materials Handling.....Dinosaur handles containers 8 through 40 cu. yd. capacity and over. Can handle two containers at a time for additional flexibility. Complete information.
66a *Dempster Brothers Inc.

Materials Handling....Pneumatic Airveyor materials handling systems flow your materials through sealed pipes. Interesting detailed literature is offered.
36 *Fuller Company

Payloader.....Model H-25 Payloader offers extraordinary protection such as cartridge-type oil filters. A booklet "Industrial Materials Handling from A to Z" is offered.
167 *The Frank G. Hough Co.

Storage Tank Equipment.....The Blue Book is a reference guide to storage tank equipment selection, design and operation and is available on request.
208a *The Protectoseal Co.

Tank & Pressure Vessels.....Large capacity vessels & tanks of mild stainless or alloy clad steel for petro-chemical, butane, petroleum & pulp industries. 16-pg. Catalog.
TR224 *Posey Iron Works Inc.

Volumatic Feeder.....New volumatic feeder machine combines vibrating hopper, feeder and controls in a single compact package. A descriptive bulletin is offered.
218B *Eriez Mfg. Co.

Weigh Feeders.....Catalog describes weigh feeders designed for the accurate feeding of dry chemicals required in water filtration and in chemical and food processes.
218C Syntron Co.

Heating & Cooling

Coolers.....Rotary Water Tube coolers give positive and effective cooling ahead of packaging, storing or further processing. Catalog "A" is available.
T221 *Davenport Machine & Foundry

Generators, Inert Gas.....offer precise fuel control & automatic safety. If you need inert gases for blanketing, purping & protective uses, see Bulletin L-10.
183 *The C. M. Kemp Mfg. Co.

Heat Exchangers.....Bulletin No. 101 gives full details on shell and tube heat exchangers available in three tube lengths and includes stacking dimensions and flow data.
218D The Griscom-Russell Co.

Heat Transfer.....Platecoil saves on engineering, fabricating and installing in comparison with pipe coils. Greater heat transfer capacity permits compact units. Bul. P61.
62 *Platecoil Div., Tranter Mfg.

* From advertisement, this issue

Plate Heat Exchanger.....Case history brochure details actual processing applications while catalog describes models ranging from 500 to 500,000 lbs/hr. capacity.
30-31 *De Laval Separator Co.

Rotating Seal.....There is a standard type and size Rotary Union for heating & cooling any revolving roll or drum. Pipe sizes ¼" through 5". Bulletin 700.
L201 *Perfecting Service Co.

Steam Traps.....Quik-Flex thermostatic steam traps are guaranteed freeze-proof when properly installed and operated. Complete information and Bulletin 257.
204 *The V. D. Anderson Co.

Steam Traps.....The 44-page steam trap book discusses trap selection, installation and maintenance. Covers its excellent air handling characteristics.
55 *Armstrong Machine Works

Steam Traps.....24-page bulletin 400 describes function and operation of steam traps, shows typical applications and gives piping recommendations plus technical information on sizing.
219A W. H. Nicholson & Co.

Instruments & Controls

Comparator.....Handbook, "Modern pH & Chlorine Control" gives theory and application of pH control. Illustrates and describes full line. Available on request.
L205 *W. A. Taylor & Co.

Computer.....Recomp 111 is the newest low-cost compact digital computer. Full information is available on its proven performance and quality.
8-9 *Autonetics Div. of N. American

Computer.....5800 Dystac computer is rated the world's most advanced analog computer. Solves problems faster and more accurately and at much lower cost.
219B Computer Systems, Inc.

Controllers.....56-page catalog covers complete line of pneumatic and electric controllers and discusses new modular design features as well as partial chart listings.
219C Minneapolis-Honeywell Co.

Controllers & Regulators.....for controlled quality in power and processing plants. Interchangeable parts and superstructures reduce costs. Bulletin 552-A.
219D Leslie Co.

Controls.....Buletin B258 is a composite catalog describing various Norwood controls and their applications to help you select the proper system.
219E Detroit Controls Div., Amer. Stand.

Controls.....ElectriK Tel-O-Set system has many features that save time in getting on stream, and keep maintenance to a minimum. No external power is required.
20-21 *Minneapolis-Honeywell

Flow Meter.....Meter used in the measurement of steam, air or gas in lines 1" and larger where accurate accounting of flow is desired, is described in 4-page bulletin.
219F B-I-F Industries, Inc.

* From advertisement, this issue

LITERATURE . . .

Gas Chromatography.....Model 20 gas chromatograph is designed for quantitative and qualitative analysis of gases. Bulletin F-9263-1.
220A Barber-Colman Co.

Industrial Gas Chromatograph..... The new Model 320C now affords management precise control of operations and more predictable profits. Data File 14-14-07.
42 *Beckman Instruments, Inc.

Instrumentation & Control.....A catalog is available which is divided into sections on control, pressure, flow, temperature, level, gas analysis and receivers.
220B Hays Corp.

Liquid Level Control.....is available for controlling level changes from ⅛" to 150 ft. Multi-stage switching when desired. Information on Magnetrol on request.
T225 *Magnetrol, Inc.

Magnetic Fow Meter.....to help solve your sticky measuring problem. The meter with no flow restrictions. Details are contained in Bulletin 20-14.
181 *Foxboro Co.

Monitoring Systems.....Omniguard is the modern, economical way to monitor temperatures and pressures. Information is available on various models.
220C Thomas A. Edison Industries

Permanent Recorder.....Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart and is designed for permanent installation.
48b *Bailey Meter Co.

Portable Indicator.....The self-contained, lightweight. Heat Prover analyzer enables quick, easy check on combustion conditions. Features dual range dials.
48a *Bailey Meter Co.

Pressure Transducer.....A simplified rugged pressure transducer for measuring fluid pressures from 100 to 10,000 psi. New data sheet is available on request.
190 *Baldwin-Lima-Hamilton

Process Transducers.....are part of the complete PowrMag line, which includes all the components for complete control systems. Further information is offered.
59 *Hagan Chemicals & Controls

Thermocouple Wells.....Nine basic types of standard pressure-tight wells, with or without T/C assemblies. Complete details in Catalog G100-5.
R236 *Minneapolis-Honeywell

Viscometers.....Bulletin V-1231 describes viscometers for vacuum & pressure applications and their many features for use with oils, resins, adhesives, etc.
220D Norcross Corp.

Pipe, Fittings & Valves

Alloy Tube.....A new high-strength copper-nickel-iron alloy. Cupro Nickel has been developed for heat exchanger tubes. Detailed information is available.
44 *Anaconda Amer. Brass Co.

* From advertisement, this issue

Ball Valve.....New Petro ball valve is available after three years of thorough research and testing. Each one is air tested to assure perfect operation. Information.
22-23 *Clayton Mark & Co.

Ball Valve.....Flo-Ball offers top entry, in-line maintenance, top & bottom guided ball, double seats, flanges integral with body and other features.
127 *Hydromatics, Inc.

Control Valves.....High pressure control valves designed & produced for your specific needs. Produced in Monel, stainless steel, Titanium & other alloys. Bulletin E-500-A.
97 *Fisher Governor

Expansion Joints.....Sola-Flex expansion joints solve just about every kind of thermal growth problem in piping or ducting. Further information is available.
76 *Solar Aircraft Co.

Flow Tube.....Lo-Loss flow tube is a differential producer having many distinctive advantages and features. Information is contained in Bulletin 405A.
221A Burgess-Manning Co.

Pinch Valve Systems....Massco-Grigsby Hydral-60 system consists of one or more pinch valves with a single automatically operated hydraulic pump. Catalog 609.
R237 *Mine & Smelter Supply Co.

Pipe, PVC.....is ideal for all kinds of applications in chemical plants because it resists corrsion, is chemically inert, eliminates scale buildup.
221B Glamorgan Plastics Div.

Pipe, PVC.....Koroseal PVC pipe is ideal for use wherever chemical resistance, high working pressures, good impact resistance are factors. Free booklet.
1 *B. F. Goodrich

Pipes, Flanges & Fittings.....An easy to use, 10" slide card gives pipe, flange and fitting information in a handy, permanent slide-rule type card. All necessary data is given.
221C Albert Pipe Supply Co.

Pipe Ratings.....Bulletin TB1-1960 lists pressure-temperature ratings of carbon steel, molybdenum, chromium silicon and chrome-molybdenum alloys in standard size seamless piping.
221D The Pipe Fabrication Institute

Solenoid Valve.....“Master-mite” is useable on a wide range of media including hydrogen, acetylene, etc. Small, but with extra strength. Special bulletin is offered.
L222 *Marsh Instrument Co.

Steam Generator Tube.....A reprint of an article describing the role of copper and physico-chemical factors in steam generator tube failures is available.
221E Dow Industrial Service

Tubing.....Thin-wall Teflon tubing for large diameter hose liners. Diameters to 4 in. available in standard 15'6" lengths. Complete information is offered.
198 *Raybestos-Manhattan, Inc.

Tubing.....Welded carbon or stainless steel tubing assure concentricity, exact O.D. and I.D., precise wall thickness & uniform ductility. Specific information is offered.
64 *Welded Steel Tube Institute

* From advertisement, this issue

LITERATURE . . .

Valve.....Bulletin 91043 contains technical data plus a specifications sheet to show advantages of the new design Tube-O-Matic valve. Send for your copy.
222A Airmatic Valve, Inc.

Valve, Ball.....The Econ-O-Miser is available from 1/4" through 6" size range & is suited to difficult media because of its smooth round flow & quarter-turn operation.
163 *Worcester Valve Co., Inc.

Valves.....A complete guide to Aloyco corrosion resistant valves is available on request. It contains a tabulation of alloy availability by design & material analysis.
R227 *Alloy Steel Products

Valves.....Sleeveline valves offer a larger sealing area, better adjustment, no pocket to collect liquids & solids. Further information in Bulletin V/14.
171 *The Duriron Co., Inc.

Valves.....Chemical Porcelain valves practically never need maintenance or replacement. Y-Valves & Angle Valves, in 1/2" to 6" sizes. Also safety valves, pipe, etc. Cat. 567.
187 *Lapp Insulator Co., Inc.

Valves.....Safety Relief valves have a special "O" ring seat seal that stops leakage completely. Available in both Standard & Balanced Bellows design. Bul. 1940.
37 *Manning, Maxwell & Moore, Inc.

Valves.....Feature a deep stuffing box for an extra amount of special packing. Valve bodies are designated with full flow areas for maximum flow conditions.
73 *Wm. Powell Company

Valves.....Ram type drain valves are designed so that in the closed position the piston or ram extends up into the tank. In open position full low is assured. Catalog.
R189 *Strahman Valves, Inc.

Valves.....for meter and gauge line service. Folder GP-9 gives specifications and engineering data on both globe & angle types, forged from stainless or carbon steel.
130 *Henry Vogt Machine Co.

Valves, Butterfly.....New butterfly valves are compact and lightweight, easy to install on any line. No lubrication is required. Full information in Catalog 613.
47 *The Lunkenheimer Co.

Valves, Check.....Duo-Chek check valve is easy to install and operates in any position. Only six parts for low maintenance with new resilient seal.
222B Mission Valve & Pump Co.

Valves, Diaphragm Control.....for accurate flow control of viscous fluids. Sizes range from 1 1/4" to 4" with larger sizes on application. Supplement catalog 356-S.
L226 *Parks-Cramer Co.

Valves, Gate.....125- and 150-pound union bonnet bronze gate valves have stronger cylindrical body design for long service life. Further information offered.
41 *Crane Co.

Welded Fittings.....Weldolets reduce piping costs. Used instead of welding tees for all full size and reducing branch connections. Information is offered.
191 *Bonney Forge & Tool Works

* From advertisement, this issue

LITERATURE . . .

Process Equipment

Agitators & Mixers.....Turbine-type propeller (to 120″ in tanks to 50″ dia.) slow speed, high speed, air lift, vertical turbine mixers, mixer-settler units. Bul. A2-B2.
196a *Denver Equipment Co.

Attrition Scrubbers.....High power input to efficiently remove sand coating, mix dense slurries. Rubber lined or acid-proof tanks. Sizes to 56″ x 56″. Bul. A-8505.
196B *Denver Equipment Co.

Batch Dryers.....These atmosphere & vacuum dryers are ideally suited for chemical salts, pigments, precipitates & a wide variety of organic products. Bulletin 118.
40 *The C. O. Bartlett & Snow Co.

Blender.....Roto-Cone blender with an atomizing spray attachment assures complete uniformity of product & eliminates wet or dry areas. Complete data is available.
194 *Paul O. Abbe, Inc.

Blender.....Double Cone blender designed for rapid mixing of dry powder and crystals with minimum of attrition. Complete information is contained in Catalog 204.
99 *J. P. Devine Mfg. Co.

Centrifugals.....feature no crystal degradation. All cycle components are pneumatically operated. Full information contained in Bulletin No. 2775.
217 *Western States Machine Co.

Collector.....This new glass cloth collector is designed for high-efficiency operation at temperatures far above the 250 deg. F. limits. Bulletin 283.
43 *American Air Filter Co.

Dissolvers.....Model 515-VHV is used for low to medium volume production while Model 5-VTV is used for small production, pilot plant or laboratory. Inform.
L236 *Morehouse & Cowles

Dryer.....Lectrodryers dry air to a very low dewpoint to keep operations on the straight & narrow path. Case history sheets and other drying help are offered.
206. *Pittsburgh Lectrodryer Div.

Dryers.....Catalog includes material on fundamentals of drying, selection of proper drying equipment and drying economics plus information on how equipment is built.
223A Hardinge Co., Inc.

Dust Collector.....Whirlex collector is completely shop assembled and need only be bolted in place at the erection site. More complete information is available.
185 *Fly Ash Arrestor Corp.

Feeders....Para-Mount vibratory feeders are available in two types-fixed rate and adjustable rate. Complete information is contained in Bulletin 611.
188 *General Kinematics Corp.

Filter.....EmicoBelt continuous belt filters successfully handle slurries that have always been considered impossible for vacuum filtration. Bulletin FE-2053 is offered.
Cover *Eimco Corp.

* From advertisement, this issue

LITERATURE . . .

Filter.....The G-140 series will remove all impurities from 25 microns on up. Cleans with a twist of the handle. Full specification and application information are offered.
52 *Purolator Products, Inc.

Filtration.....A line of filter Presses, Closing Devices, and Filter Media for your filtration problem. Also complete research & engineering service. Catalog.
101 *D. R. Sperry & Co.

Flash Drying Systems.....offer flexibility in application. This is a versatile system that can be readily adapted to your particular problem. Catalog # 82E.
128 *Combustion Engrg. Inc.

Floats.....Industrial floats feature corrosion resistance, extreme strength, buoyancy and dependability. A complete bulletin is available on styles, sizes, etc.
TL 224 *Chicago Float Works

Hammer Mills & Pulverizers.....Technical catalog discusses complete line of heavy duty hammer mills and screen type pulverizers and includes detailed dimension tables.
224A Young Machinery Co. Inc.

Jaw Crusher.....with cast steel frame, anti-friction side bearings and bumper bearings are covered in detail in Bulletin C12-B12. Sizes from 2¼" x 3½" to 36" x 48".
196d *Denver Equipment Co.

Liquid Blending.....Vari-Flo proportioners and new concepts in continuous line blending are detailed in bulletin. Equipment designed for flow rates between 1 and 2000 gpm.
224B Blackmer Pump Co.

Mills, Ball & Rod.....in sizes 10' x 20'. All steel construction for wet or dry grinding systems. Additional information contained in Bul. B2-B20.
196c *Denver Equipment Co.

Mixer.....New Tur-Blend mixer is a vertical vessel with an internally & centrally positioned material lifting screw. Information in "Facts & Figures".
169 *Goslin-Birmingham

Mixers.....Bulletin describes double arm mixers designed for the processing of viscous fluids and semi-solids. Detailed information on construction features is given.
224C The J. H. Day Co.

Mixers.....New Shear-Flow continuous mixers cut processing cost, eliminate costly equipment and offer versatile adaptability. Further information in Bulletin RL-200.
192 *Gabb Special Products, Inc.

Molecu-Dryer.....A new type MSX molecu-dryer has been developed to supply pure, dry air at 100 deg. F. & solve instrument air problems. Full details in Bulletin 1060C.
L 189 *C. I. Hayes, Inc.

Plastic Pall Rings.....are injection molded in four sizes: ⅝", 1", 1½" & 2" in polypropylene & on special order in rigid PVC or polystyrene. Engineering Data.
78 *U. S. Stoneware

Process Equipment.....Brochure describes process services including distillation, air pollution control, absorption, vacuum deaeration, etc. Send for your copy.
224D Colonial Iron Works Co.

* From advertisement, this issue

Process Equipment.....“Sub-A” Flotation is available in sizes from 16″ x 16″ to 72″ x 72″. “Cell-to-Cell”, “Free-Flow”, and Type “M”. Bulletin F10-B86.
196f *Denver Equipment Co.

Proportioning System.....Continuous liquids-to-solids proportioning system adapts to a wide range of applications. Facts booklet is available on request.
L257 *B-I-F Industries

Reagent Feeders.....Both wet and dry feeders are available. Many standard units in stock. Complete information on these feeders in Bulletin F6-B8.
196e *Denver Equipment Co.

Rotary Blenders.....are available in 9 standard models with capacities to 900 cu. ft. Feature self-cleaning dust-sealed drum. Bulletin 080B for more information.
R256 *Sturtevant Mill Co.

Samplers.....Continuous mechanical & automatic types for dry, solution or slurry sampling. Complete sampling plants & sample processing equipment. Bul. S1-B4.
196j *Denver Equipment Co.

Screens.....for efficient wet or dry screening. “True-Circle” eccentric action. Sizes to 6′ x 14′ in stock. Trommel Screens in sizes from 30″ x 60″ x 120″. Bul. S3-B15.
196k *Denver Equipment Co.

Separators.....Vibro-Energy separators offer quick screen change & longer screen life to cut operating and maintenance costs. Full details & application data are offered.
50 *Southwestern Engrg. Co.

Spiral Rake Thickeners.....move settled materials to center in one revolution. Acid proof construction available. Further information in Bul. T5-B6.
196l *Denver Equipment Co.

Spray Dryer.....4-page bulletin discusses special-design spray dryers for pilot plant and hard-to-dry materials. Specifications of air heating, chamber sizes and construction are given
225A Bowen Engineering, Inc.

Vacuum Dryers.....designed to meet your specific needs. A new booklet, “Handy Guide to Vacuum Dryer Selection” has been prepared & is available on request.
28-29 *F. J. Stokes Corp.

Pumps, Fans & Compressors

Centrifugal Pumps.....4-page illustrated bulletin describes impervious graphite type F centrifugal pumps that provide capacities up to 140 gpm and head up to 67 feet.
225B National Carbon Co.

Compressor.....Bulletin describes a new heavy-duty rotary compressor for general purpose services, including those requiring delivery of oil-free air, gas or vapor.
225C Fairbanks, Morse & Co.

Compressor, Piston.....assures absolute contamination-free compression of dry or moist gases. Unique ringless piston & frictionless piston rod. Information & specifications.
184 *Sulzer Bros., Inc.

* From advertisement, this issue

LITERATURE . . .

Compressors.....“Dry Cylinder” compressors protect your product by complete separation of cylinder and crankcase. Information in Bulletins VE-100 & VE-102.
215 *Corken's Inc.

Cryogenic Pump.....for low-temperature pumping of oxygen, nitrogen, argon, methane. Highly efficient. Stationary or truck mounted. Further details are offered.
B225 *American Messer Corp.

Displacement Blowers.....bulletin describes rotary positive displacement blowers that provide constant metered quantities of gas or air even against varying pressures.
226A Sutorbilt Corp.

Jet Compressors.....New bulletin on companies line of jet compressors includes fixed nozzle, manually controlled spindle and automatically controlled spindle types.
226B Schutte & Koerting Co.

Pump....Type DPL self-priming pump gives assured performance and dependable, trouble-free economy. For your toughest jobs or routine applications. Details.
72 *La Bour Company

Pumps.....Turbine Pot pumps offer true pumping economy and versatility. They are compact and ruggedly built for longer life & continuous, trouble-free operation.
177 *Fairbanks, Morse & Co.

Pumps.....Model 3195 pumps simplify process engineering and cut parts inventories. They offer maximum interchangeability. Bulletin.
26-27 *Gould Pumps, Inc.

Pumps.....Mayno pumps are available in capacities to 500 gpm; pressures to 1000 psi. For corrosives, suspended solids & abrasives. Bulletin 100-XX.
51 *Robbins & Myers

Pumps, Diaphragm.....Stroke can be adjusted while pump is operating. Sizes 1" to 10" simplex and duplex, capacity to 1000 gpm. Bulletin P8-B-12 offered.
196g *Denver Equipment Co.

Pumps, Metering.....for biological, industrial or sanitary use feature fixed or variable capacities and extremely compact design. Complete details & prices offered.
B219 *Mechanical Products Corp.

Pumps, Rotary.....custom designed to solve particular problems and reduce costs at the same time. Further information is contained in Folder 61C.
B220 *Viking Pump Co.

Pumps, SRL (Rubber Lined).....Now available in “TRU-Glandless” construction. No sealing water, no packing glands, no slurry dilution. Additional information in Bul. P9-B28.
196i *Denver Equipment Co.

Pumps, Vertical Centrifugal.....for handling frothy liquids or coarse, sand slurries, constant or intermittend flow. Capacity to 450 gpm. Bulletin P10-B5.
196h *Denver Equipment Co.

Submersible Pumps.....Bulletin describes line of high capacity 3550 rpm and 1750 rpm submersible pumps for industrial, commercial, institutional and municipal water systems.
226C Sumo Pumps, Inc.

* From advertisement, this issue

LITERATURE . . .

Services & Miscellaneous

Chemical Cleaning.....6-page pamphlet describes importance and methods of chemically cleaning tanks, transfer lines, valves etc. used in missile launching.
227A Dow Industrial Service

Construction.....Critical Path Scheduling consists of the analytic appraisal of all jobs to be done & logical determination of their timing and sequence.
93 *Catalytic of Canada, Ltd.

Distillate Treating.....Booklet gives detailed description of electrofining processes used to treat distillates and middle range oils; also describes catalytic sweetening process.
227B Petrolite Corp.

Engineering Knowledge....Booklet E-2, "Personal, Professional Advancement" discusses the development of a successful career through constant, consistent dedication.
R238 *Western Supply Co.

Film Guide.....1961 catalog lists 223 films and includes alphabetical and subject indexes. Subjects range from Home Economics to Laboratories, Research & Production.
227C Manufacturing Chemists' Assoc.

Reactor-Clarifier.....Booklet describes water treatment unit that combines flocculation and clarification in a single tank. Drawings show flow patterns through sections.
227D The Eimco Corp.

Refuse Collection .....When mounted on Dinosaur, the Dinomaster provides no-container-haul service for refuse containers, one through eight cu. yds. Information.
66b *Dempster Brothers Inc.

Safety Equipment.....The new Red Book contains flammables engineering fundamentals and complete line of safety containers and operating equipment.
208b *The Protectoseal Co.

Scale Models.....The whys' and hows' of using scale models as an engineering tool are outlined from preliminary design through construction in 6-page brochure.
227E Industrial Models, Inc.

Steel Floor Plates.....Leaflet describes floor plates that do not require maintenance and will hold up under heavy loads. Safety-friction surface provides good traction.
227F Rockwell-Standard Corp.

Water Service.....Bulletin 10 gives general facts and information on water well systems, water pumps, well drilling and allied water services.
227G Layne & Bowler, Inc.

Water Treatment.....Selection of proper type of water treatment equipment for use at different pressures and with different water is the subject of 10-page article.
10-page article.
227H Graver Water Conditioning Co.

Water Treatment....Flocculation, clarification and filtration equipment are combined in modular units and sized to your requirements. Full details are offered.
212 *Hardinge Co., Inc.

* From advertisement, this issue

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Equipment Searchlight

CE's Searchlight spots the big bargains in used, resale and rented equipment. Check this issue's listings—most complete in the field—for items you need now.

▶ **Coverage** — National. Equipment and facilities—used, resale and rental—for the process industries. For sale, wanted, for rent.

▶ **Rates**—$21.75 per inch for all ads except on a contract basis; contract rates on request. An advertising inch is measured ⅞ in. vertically on a column; 3 columns, 30 in. per page. Ads acceptable only in display style.

▶ **Closing date**—May 1st issue closes April 7. Send all new ads to Chemical Engineering, Classified Adv. Division, P. O. Box 12, New York 36, N. Y.

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9 Gen. Elec. 20, 25, 45, 65, 70, 80, 100, 125 Ton
25-Ton Industrial Brownhoist, 60' Boom Crane
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PLANT EQUIPMENT
4' Traylor TY Gyratory Crusher
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No. 1 Sturtevant Rotary Fine Reduction Crusher
F55 Syntron Grizzley Feeder
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Hardinge Mills: 3' x 8', 3' x 24" & 5' x 22"
Rod Mills: 4' x 11', 6' x 12' & 7' x 15'
Jaw Crushers: 8" x 10", 10" x 20", 14" x 28", 18" x 36", 30" x 36", 48" x 60", 48" x 72", 66" x 84"
Crushers, Fine Reduction: 22", 2', 3', 4', 5½' & 7'
Crushers, Roll: 24" x 14", 30" x 14", 40" x 16"
Rotary Dryers: 3' x 30', 5' x 30', 6' x 50', 6' x 70' & 8' x 80'
Rotary Kilns: 36"x30', 6'x70', 7'x120' & 9'x160'
2—42" x 120" Buflovak Atmos. Double Drum Dryer
Roto Louvre #207-10 Type 316 SS, Link Belt
150—1½, 2 & 4 yd & 30 yd Dump Cars
7'x120' Allis Chalmers Rotary Kiln ⅝" welded shell
Laboratory Rotary Kiln, 36" x 30'. Complete
4' x 10' Tyler-Hummer Electric Vibrating Screen
2'x 6' & 3'x12' Seco Single Deck Vibrating Screen
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16' Gayco Centrifugal Air Separator
BX-100 Sutton Steele & Steele Air Table NEW
6—30" x 32" Dings Magnetic Head Pulleys
690', 2200', 3068' & 3600-IR Compressors
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Vertical agitator and baffle. Glass good for severe acid service. Six months use. Excellent.

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138 CFM 100 PSI 7X7, Ing. ES, CP & Joy
288 CFM 100 PSI 9x9 Ing. Worth, CP
294 CFM 125 PSI 9x9 Joy WG-9
311 CFM 1500 PSI 10½-7⅛-3½-13 IR-ES3
351 CFM 350 PSI 11-5x11 CP TCB-2
465 CFM 100 PSI 12x11-IR-ES CP.T. Worth HB
502 CFM 125 PSI 12x13 Worth HB
593 CFM 110 PSI 13½-8½ x 8 Worth, DC 2
686 CFM 100 PSI 14x13 Ing. ES
1050 CFM 60 PSI 13-13x12 IR-XRE
1290 CFM 125 PSI 13/8x7 Joy WN114-E
2200 CFM 100 PSI 26-15x18 Ch. Pn. oce 350 HP 3-6-4160-4600-8 PF
2520 CFM 125 PSI 17-10½x8 Clark CMA-4L
3330 CFM 45-215 PSI Clark—CMA-6

AMERICAN AIR COMPRESSOR CORP.
Chem. Road, North Bergen, N.J. UNion 5-1397

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Unique new conception Parallel Spray Dryer, only 32 ft. high, 1000 lbs. water evap/hr. 100% unbroken heads recovered. Instant-soluble products, foods, vegetable chemicals, soaps. By designer original patented Concurrent Dryer. Best ref. Any solids-containing liquids.
Write Secheurs Atomiseurs Co., 11 Ave., Grande Bretagne, Monte Carlo, Monaco.

CIRCLE D ON READER SERVICE CARD

BOILERS: HIGH PRESSURE. We carry a large selection of ASME, National Board high pressure boilers, gas, oil and coal fired, ranging from 10 to 4,000 HP. Each guaranteed in excellent condition. Sale sheet and complete data sent upon request. Write to:
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IN dependence 3-0303 and 04.

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Searchlight Equipment Locating Service
Classified Advertising Division
Chemical Engineering
P.O. Box 12, N.Y. 36, N.Y.

Your requirements will be brought promptly to the attention of the equipment dealers advertising in this section. You will receive replies directly from them.

Searchlight Equipment Locating Service
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CHEMICAL ENGINEERING
P.O. Box 12, N. Y. 36, N. Y.

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LIQUIDATION
OMAHA, NEBRASKA

MAJOR ITEMS

5—Buflovak 42" x 120" dbl. drum dryers, ASME 160#

2—American 36" x 84" double drum dryers

2—Bonnet 7' x 60' rotary dryers

1—Bonnet 6' x 52' rotary dryers

9—Davenport #1A #2A dewatering presses, vari-drives

2—French Oil type 2-S screw-type extraction presses 300 PSI, 60 HP.

2—Sweetland #12 pressure filters

6—Shriver 48" Cast Iron P. & F. filter presses, (50) chambers, hydraulic closure, closed deliv.

2—19,900 sq. ft. quadruple effect calandria type evaporators, copper tubes, cast iron bodies

6—Ansonia 691 sq. ft. dbl. pipe coolers, copper tubes

3—American 654 sq. ft. spiral steel heat exchangers

18—Tubular heat exchangers, copper tubes: 1500, 1350, 1130, 637, 380, 290, 184, 176, 156 sq. ft.

4—Leader Iron 96" dia. steel rectifying columns, 44' & 51' high.

2—9500 gal. horiz. cookers, 9' dia. x 20' long, ½" shell & heads.

5—Forster hammermills, #8 & #6

2—Allis-Chalmers Inter-plane grinders, 100 HP

9—Davenport 5' x 25' screens

2—Warren 12" x 12" cent. pumps

250—Steel centrifugal pumps, 1" to 12", 1 HP to 150 HP

2—Aldrich vert. triplex plunger piston-type pumps, steam drive, 162 GPM @ 175# WP.

3—1000 KVA trans., 13800—460 v.

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1413-21 N. Sixth St.
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Phone POplar 3-3505

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Pfaudler 500 gal. ELL Reactor Jkt. & Agit.
B&P 300 gal. Stainless 18DIM Sigma Mixer
Dopp 1000; 1700 gal. Reactors Jkt.; Agit.
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Goslin Birm. 36"x24" S.S. Rot. Vac. Filter
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Sharples C27 Super-D-Hydrator 316 S.S.
A.T. & M. 40" & 30" S.S. Susp. Centrifuges
Buflovak 6' Crystallizers Atmos. & Vac.
Swenson 24"x20' Jktd. SS316 Crystallizers
Nash #9, #4, K5 & TS10 Vacuum Pumps
Squire 500 Sq. ft. Tray/Truck Dryer
Stainless Packed Columns, 12"x20'; 36" x21'
Stainless Bubble Cap Columns 36"x17'; 48"x40'; 54"x30'; 72"x30'; 78"x18'
Copper Bubble Cap Columns 2' to 6' dia.
Stainless Condensers—68 to 1000 Sq. ft.
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Steel Tanks 250 to 22,000 gal.
Centrifugal Pumps Stainless 1"; 1½"; 2"
Norwalk 5 Stage Compressor 15000 PSI
Roots Connersville Blowers 18"x18"; 20"x20"
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HEAT & POWER CO. INC.
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Site Office, Pine Ave. & 47 St.
BU 5-3644

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Fletcher 30" Stainless Steel Basket Centrifuge.
Raymond Model "O" Pulverizer
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Mikro No. 6 S.S. Atomizer and Bantam, 1SH, 2TH, 3TH, and 4 TH Pulverizers
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Kettles: 69 Lee 40 gal. stain. clad, 40# WP.
Kettles: Other makes and sizes.
Column: 24" x 22', 316 stain. steel.
Disintegrators: Rietz RD-18-P and RD-12.
Dryer: American 24x48" dbl. drum.
Dryer: Bowen lab. spray, st. st.
Evaporator: Buflovak sgl. eff. st. st. 94 sq. ft.
Dryer: Porter 2 x 4' vac. drum., st. st.
Centrifugal: Tolhurst 26" rubber, 2-speed.
Filter: Sweetland #5 st. st. lined.
Filter: Eimco, drum 18" x 12".
Vacuum Pans: 42" and 72" stain. steel.
Dryer: Proctor & Schwartz 6-tray st. st.
Centrifugal: AT & M 60" st. st. perf.

Write us or call Seeley 8-1431
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Very modern General Electric and Allis-Chalmers 750, 1000, 1500, 2000 and 3000 KW
600 Volts D.C., 13,800 Volts AC
Complete with Transformers and all controls

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CIRCLE T ON READER SERVICE CARD

Dowtherm 225 KW
Autoclave S.S.—50 gal—2000 lb. pres.
Autoclave S.S.—3½ gal—2000 lb. pres.
Proctor & Schwartz finned drum drier
Centrifuge S.S. 26"—Tolhurst
2 Evaporating Dishes—jacketed S.S. 71" dia.
1 Kettle S.S.—jacketed—500 gal.
2 Kettles S.S. Jacketed—agitated—250 gal.

MACHINECRAFT CORPORATION
800 Wilson Ave. (East of Doremus)
Newark 5, N. J. MI 2-7634

CIRCLE P ON READER SERVICE CARD

ECH SPECIAL
Abbe Eng. Jacketed 5' x 6' Ball Mill, chrome manganese steel. Price $2750.00
EQUIPMENT CLEARING HOUSE, INC.
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SOuth 8-4451—4452—8782

CIRCLE U ON READER SERVICE CARD

Hersey 5'x26' Rotary S.S. Dryer
New 4000 gal. Stainless Tank
Day Hy-R Speed Mill 20 HP XP
SEND FOR LISTINGS
STEIN EQUIPMENT CO.
107—8th Street Sterling 8-1944 Brooklyn 15, N. Y.

CIRCLE V ON READER SERVICE CARD

BOILERS
HI-PRESSURE
turbogenerators, pumps, fans,
Nation's largest inventory, New & Used
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CASH— $ $
FOR YOUR IDLE MACHINERY
ME MACHINERY AND EQUIPMENT CO.
123 Townsend St. · San Francisco 7, Calif.

CIRCLE X ON READER SERVICE CARD

Get off the fence—Get extra profits—**Buy**

GELB

CHEMICAL PROCESS EQUIPMENT

1—Sharples type 316 SS Super-D-Canter, PN-14, complete
1—Sharples type 316 SS centrifuge, D-2
3—Pfaudler glass lined thimble type condensers, 14 sq. ft. and 9 sq. ft.
1—Buflovak lab. pilot plant 6" x 8" chrome plated doub drum dryer with variable speed drive

AUTOCLAVES, KETTLES, REACTORS

1—Pfaudler Series E1 750 gal. glass lined reactor, jacketed
2—Pfaudler Series EM 300 gal. glass lined jacketed reactors
2—Theo. Walters 300 gal. Hastelloy B jacketed reactors
1—Van Aist 300 gal. stainless steel jacketed kettle
1—Blaw Knox 300 gal. stainless steel vacuum reactor
1—Struthers Wells type 316 SS 2000 gal. jacketed reactor
2—Blaw Knox steel 600 gal. autoclaves

DRYERS

2—Bonnet rotary kilns, 8' x 115', complete
1—Bonnet rotary cooler, 8' x 50', complete
1—Allis Chalmers stainless steel rotary dryer, 6' x 50', complete
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
2—Link Belt steel roto louver dryers, Model 207-10, 604-20
2—Buflovak stainless steel rotary vacuum dryers, 5' x 30'
1—Hersey rotary dryer, 3' x 20', complete
1—Buflovak SS jacketed rotary vacuum dryer, 3' x 15'
2—Stokes SS jacketed rotary vacuum dryers, 3' x 15' and 2' x 6'
1—American 42" x 120" double drum dryer, ASME, complete
3—Buflovak steel jacketed rotary dryers, 3' x 15', 5' x 20', 5' x 35'
2—Stainless steel pilot plant spray dryers
1—Stokes single door vacuum shelf dryer, 6 shelves

CENTRIFUGES

1—AT&M 48" SS suspended type centrifuge, complete
1—Fletcher 48" SS underdriven centrifuge, complete
7—Western States 40" type 316 SS suspended type centrifuges
1—AT&M 26" type 316 SS suspended type centrifuge, complete
5—Tolhurst 40" and 30" rubber covered centrifuges

FILTERS

12—Sweetland #12 filters with 72 stainless steel leaves
1—Niagara stainless steel filter, Model 510-28
1—Oliver SS rotary vacuum pressure precoat filter, 5'3" x 8'
1—Oliver horizontal filter, 3'
1—Oliver stainless steel rotary vacuum filter, 3' x 4'
1—Shriver aluminum 30" x 30" P&F filter press, 30 chambers
10—Shriver plate and frame filter presses, 12" to 42"

MIXERS

1—Banbury #1 mixer with 30 HP motor
1—Sturtevant #7 dustite rotary batch blender, NEW

THE GELB GIRL—APRIL 1961

15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Robinson type 304 SS horizontal double ribbon blender, 125 cu. ft.
1—Baker Perkins, Size 16, Type UUEM, 150 gal. jacketed, double arm dispersion type mixer, complete with compression cover and 100 HP motor
1—Baker Perkins SS double arm sigma blade mixer, 9 gal.
1—J. H. Day 5 gal. double arm sigma blade mixer, SS
1—Stokes stainless steel granulating mixer, Model 21-J
1—Colton stainless steel granulator, Model 561-S

MISCELLANEOUS

1—Williams "Comet" 4 roll mill, complete
1—Raymond 2 roll high side mill
1—Stewart Bolling 2 roll chrome plated, plastic mill, 8" x 16"
1—Ross 6 "x 14" 3 roll paint mill, high speed, complete
1—Vulcan stainless steel bubble cap column, 4' x 25 plates
1—Badger SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with trays
1—Griscom Russell SS heat exchanger, 900 sq. ft.
1—Downington SS heat exchanger, 750 sq. ft.
3—Badger SS heat exchangers, 500 sq. ft. and 600 sq. ft.
4—Patterson SS condensers, 200 and 300 sq. ft.
20—Davis Engineering SS heat exchangers, 102, 119, 136, 166 sq. ft. NEW
2—Davis Engineering Carpenter 20 heat exchangers, 120 sq. ft.
2—Swenson SS vacuum crystallizers, 3'6" x 12' and 2' x 12'
3—Mikro #1SH pulverizers, complete
1—Mikro #2TH pulverizer, complete
2—Mikro #3TH SS pulverizers, complete

1—Raymond #5057 high side five roll mill
1—Cleaver Brooks 500 HP package steam generator, 200#
1—Sprout Waldron pelletizer, Type 501 FF
2—Pfaudler type 316 SS jacketed reactors, 200 and 100 gal.

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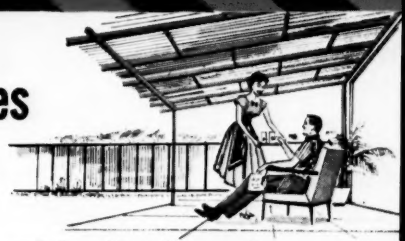

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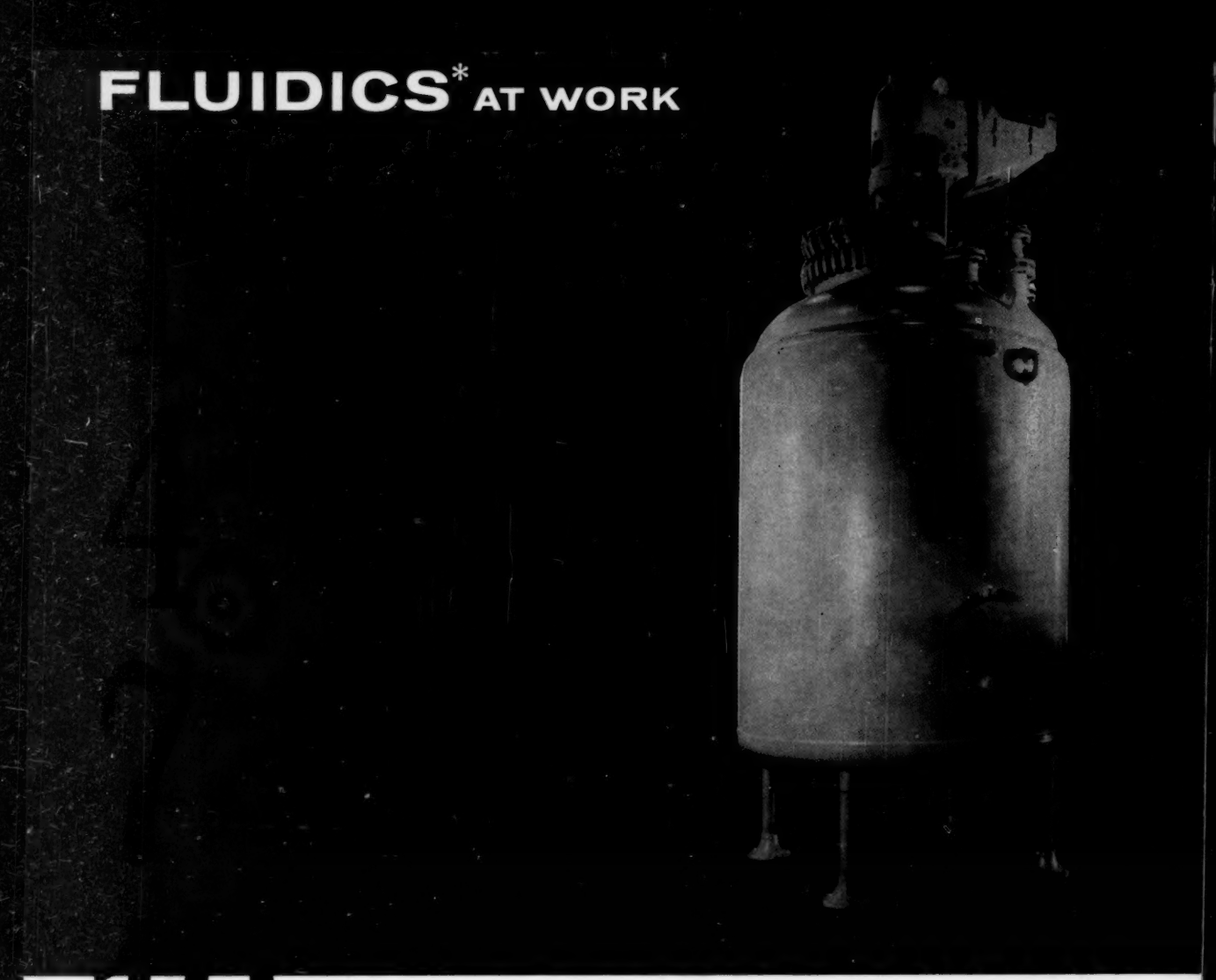

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300 gallon, 4TW variable speed drive, 7½ h.p. motor, agitator speed 32-150 RPM.
500-gallon, 4TW variable speed drive, 7½ h.p. motor, agitator speed 32-150 RPM.

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750-gallon, 5TW drive, 3½" rotary seal, 7½ h.p. motor, 90 RPM.
1000-gallon, 5TW drive, 10 h.p. motor, 117 RPM.
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